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ABSTRACT

This document contains two volumes of papers presented at the first annual meeting of the International Organization of Science and Technology Education Symposium. Each volume of papers is divided into two sections. Section 1 of the first volume focuses on relevant teaching, incorporating curriculum, teaching approaches, and assessment aspects. Section 2 of Volume One papers focus on environmental issues including sustainable development and a culture of peace. Papers included in Section 1 of Volume Two focus on action research, involving classroom related studies and professional development studies. Section 2 of Volume Two papers focus on resources supporting teaching, including locally produced equipment, visualization ideas and using new technologies. (YDS)

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Preparing Future Citizens.

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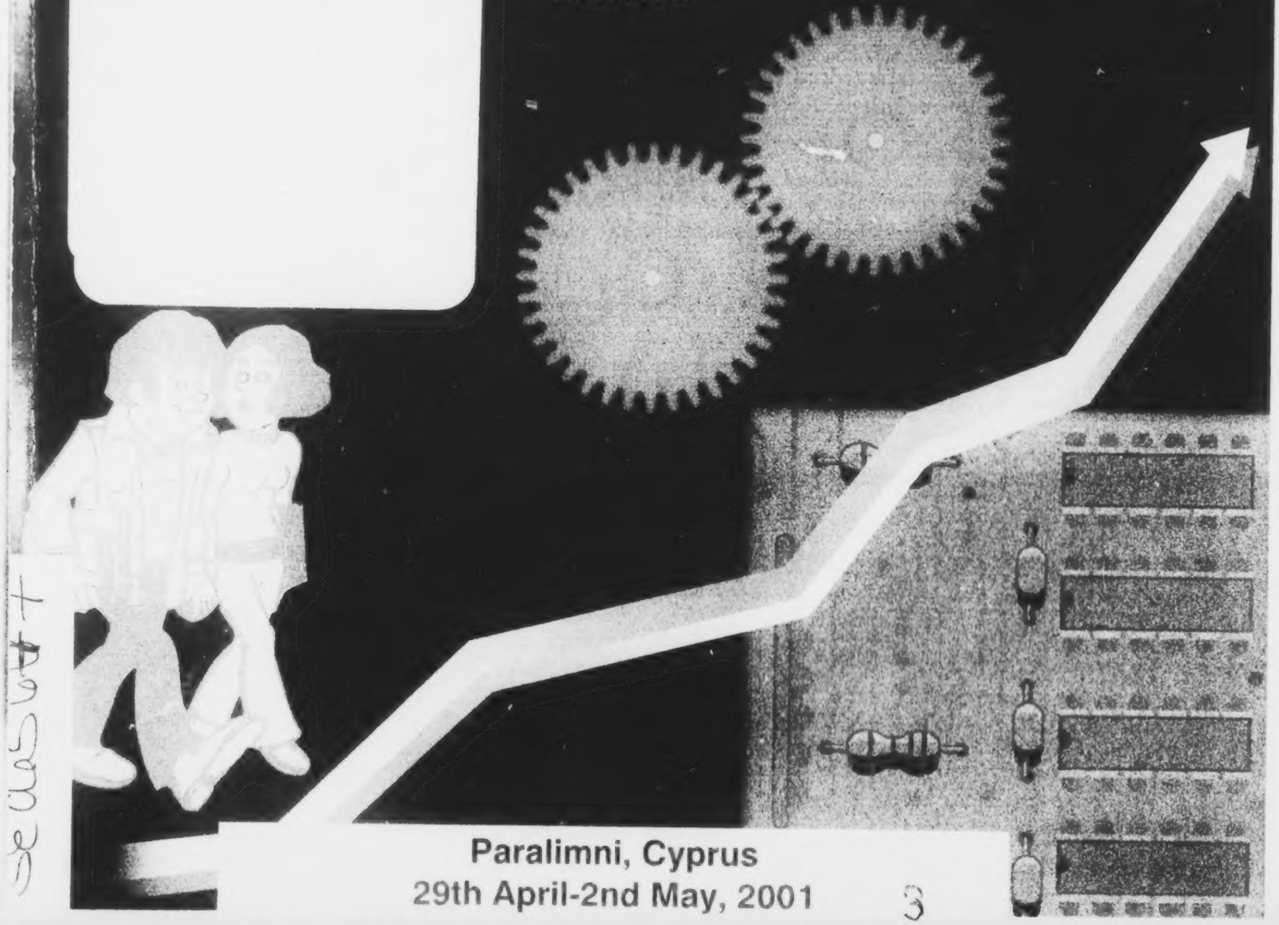
1st IOSTE Symposium in Southern Europe

SCIENCE AND TECHNOLOGY EDUCATION:
Preparing Future Citizens

Volume I



Paralimni, Cyprus
29th April-2nd May, 2001

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1st IOSTE Symposium in Southern Europe

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SCIENCE AND TECHNOLOGY EDUCATION:

PREPARING FUTURE CITIZENS

VOLUME I

SECTION 1:

Relevant Teaching, Incorporating Curriculum, Teaching Approaches, and Assessment Aspects

SECTION 2:

Environmental Issues, Including Sustainable Development and a Culture of Peace

Paralimni, Cyprus
29th April – 2nd May, 2001

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Invited Speakers:

George I. Za'rour, Formerly Professor at the American University of Beirut and Senior Educator at the World Bank in Washington, D.C.

Rosanne W. Fortner, The Ohio State University, USA

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Preface

When you embark on a journey, wish that the road to your destination would be adventurous, full of experiences and knowledge for you to gain. Wish that in your travels you will find others to share these experiences with, and together to construct ways about how to successfully find the way to your Ithaki - just like Ulysses did with his men, when for more than 20 years he was desperately trying to return to its hometown Ithaki.

As some of you might have realized, I just paraphrased some verses from the poem Ithaki of the Greek poet Constantinos Kavafis, because of its relevance to our case. For Ulysses, the objective was to reach his homeland Ithaki; for us, it was to organize this conference and invite all of you to come to the hospitable town of Paralimni, Cyprus. You responded to our invitation and you came here not just as visitors but also as concerned science and technology educators striving to promote the objectives of our community. At a time when much attention is being placed on **'Education for All'** and the role played by science and technology education in providing a relevant education for all future citizens, we unanimously agreed that it was appropriate to draw attention to the role of science and technology education. **"SCIENCE AND TECHNOLOGY EDUCATION: Preparing future citizens"** was announced as the theme of the **"1st IOSTE Symposium in Southern Europe".**

As we all know, there has been a strong tradition of rewarding excellence in science and technology, even at the expense of relevance for all, but for the new millennium there is a need to find ways to combine the two. How is it possible to provide a strong science and technology background for those wishing to pursue these subjects to a higher level and yet, at the same time, provide an appropriate and rewarding science and technology experience for all students. In other words, instead of portraying science and technology as subject matters where success is largely measured by memorization of facts, the efforts are directed towards popularizing science. The purpose is to increase public awareness for future citizens by encouraging student participation in problem solving and decision-making activities. These were the main concerns of our IOSTE Symposium.

We really appreciate your willingness to join us here and share your research evidence, your ideas, and concerns with us. Despite the long and difficult process of organising the **"1st IOSTE Symposium in Southern Europe",** we conclude with the verses of the poem Ithaki wishing a long and difficult road to our destination, because the experience was invaluable and rewarding. We worked together to construct educational visions, goals, plans, and directives. We used our minds together to make sense, decide, plan, and take action. But gradually what became most important to us was *interacting and collaborating with you. During this process, we engaged in conversations, shared insights, and established links between your interests and our interests. A community of practice started to form.*

We aim with this conference to start a dialogue about our field of study and sustain this dialogue through collaboration that will continue well after this conference ends. We have been suffering from feelings of isolation and it is only by fighting these feelings of isolation that we will be able to advance our thinking and practices. We also strive with this conference to bring scientists, researchers, and practitioners together to form partnerships and inform one another for the purpose of better educating our children.

The theme of our conference was how to prepare our students to become science-and-technology literate. We live in an age of continuous scientific and technological advancement. How should we educate our students to survive in a rapidly changing world? How should we make education relevant to real life? Science is life itself and there is a need to design powerful learning environments in which learners experience the discipline of science as relevant to their everyday life. In these environments, the learner is no longer considered an empty vessel or a passive recipient of information that someone else delivers. The learner explores, constructs, and problem-solves within a context, and actively communicates and interacts with the teacher and other learners.

In the first volume of the proceedings, members from our community of practice share with you their insights about how ***"Relevant Teaching, incorporating curriculum, teaching approaches and assessment aspects"*** *can be designed to prepare our students to become science-and-technology literate citizens. Citizens that will be well informed to understand, make decisions and take actions related to* ***"Environmental issues, including sustainable development and a culture of peace".***

Cordially,

NValanides

Dr Nicos Valanides
Chair of the Organizing Committee

Relevant Teaching, Incorporating Curriculum, Teaching Approaches, and Assessment Aspects

Relevant Teaching: Incorporating Curriculum, Teaching Approaches, and Assessment Aspects

George I. Za'rour, *GIZarour@aol.com*
Formerly Professor at the American University of Beirut
and Senior Educator at the World Bank in Washington, D.C.

THE ISSUE OF RELEVANCE

Let me start by taking the liberty of changing the topic slightly and add /Learning next to Teaching. The organizers may point out that this is assumed, but it is worth emphasizing in this day and age when learning is gaining grounds over teaching. To have these processes of learning and teaching *relevant* requires linking them to relevant goals. But goals relevant to whom? Is it to the international community of nations, or a group of nations like the European Union, or is it to what IOSTE defines as Southern Europe? Is it to the concerned country, or to a community within a country? IOSTE is one of the logical platforms to respond to the challenge that technological and environmental policies and actions (or inactions) that take place in opne country or locality may have global consequences. Chernobyl, bombarding bridges in one section of the Danube, mad–cow disease, and the potential threat of ammunition made of depleted uranium – are few examples that had impact on southern Europe in the recent past.

Who decides and on what basis what science or technology should students learn and teachers teach? It is true that the world has shrunk and became interrelated in ways not even imagined few decades ago. Yet, it is also true that there are pioneers and leaders, on the one hand, and followers/imitators, on the other and many others in between – a scenario which, when applied to relevance, covers a wide spectrum. In many centers that develop curricula worldwide, libraries are stacked with sample curricula and textbooks from all over the world. No wonder, science curricula across countries have more similarities than differences. It is more appropriate to advocate that each country define its goals and assess relevance in terms of those goals. Unfortunately, in many a country, the goals are written in lofty terms directed at public relations. Many science curricula developed even four or five decades ago included superb goals – calling for development of scientific skills, critical thinking, problem solving, and objectivity among others. But the end product or output of the educational systems left/leaves much to be desired mainly because the resulting curriculum, and the teaching approaches and assessment activities used to implement it – did/do not contribute to realizing those goals.

With the breadth of the revolution in information technology and communications, many aspects of globalization have become a way of life irrespective of treaties such as the World Trade Organization. Nevertheless, anxieties emanate from the fact or expectation that globalization will leave behind inequalities in prosperity and in health, education and access to the Internet. In the current international context, which is more relevant: teaching about AIDS and the ways through which it is transmitted or abstaining from teaching any material that touches upon sexual relationships? Which is more relevant: providing information and developing attitudes that promote keeping the environment free of pollution, or memorizing formulas of pollutants without dramatizing their impact on community health, the seas and rivers? A recent report by an American commission headed by Senator/Astronaut Glenn (2000) includes the following among the reasons underscoring the need for American children to achieve competency in mathematics and science: (a) the rapid pace of change in both the increasingly interdependent global economy and in the American workplace; (b) citizens need math and science for everyday decision–making; and (c) the deeper, intrinsic value of mathematical and scientific knowledge shape and define our common life, history, and culture.

With the rapid changes in science and technology, relevance becomes closely tied with enabling the learner to adapt to change. One has to be ready to change several careers during a lifetime and to be a continuous learner in order not to be left behind in an increasingly competitive world. To meet the needs of knowledge–based economy, education and training have to concentrate on the development of abilities to effectively acquire, deliver and process information. As technological changes render specific skills obsolete at a rapid rate, learning how to learn assumes additional importance. Many developing countries want more students to specialize in scientific and technological fields. It often happens that those countries do not have enough jobs for graduates in those fields. Unfortunately, the alternative is to specialize in literary and other non–science fields of study where the employment chances are not any better. Who determines relevance in such situations in the presence of a mismatch between the output of the education system and labor market requirements. But nowadays, labor market requirements are in a state of continuous flux. The challenge for all countries is in preparing for tomorrow's jobs, unknown as they are, through higher and better educational attainment. Countries like Germany and the U.K. are copying the American practice of attracting information technology talent from less developed countries. Their success is impacted by the prevalence of social/political attitudes towards immigrants, in general, and certain categories, in particular.

Since the launch of Sputnik in 1957, if not before, alarms have been sounded periodically in America about the poor quality of science and mathematics education. Following the results of the earliest participations in international evaluation activities, American educators were more on the defensive rationalizing the inferior performance relative to other countries. Later, there was more recognition and acceptance of the problems and the need to address the issues. This was reinforced by the attention of parents and politicians and the ensuing generous allocation of funds to improve quality. In the past couple of decades, corporations and businesses joined the efforts and became more involved and interested in enhancing the quality of education, as it was increasingly realized that U.S. economic and scientific dominance is threatened when schools do not produce enough scientists, engineers and other technically skilled workers.

Several educators and researchers view these crises in education with skepticism. The false crisis in science education was debated by Gibbs and Fox (1999) who stated that "A consensus has begun to emerge among science education researchers, teachers, and practicing scientists that schools should turn out scientifically literate citizens, not more candidates for the academic elite". The *National Science Education Standards* (p. ix) emphasize achieving scientific literacy in the American nation as a major goal. The pressure to raise test scores and face accountability measures results in overlooking relevance and what schools ought to teach about science and math. William McComas of the University of Southern California is quoted stating in the debate that the "false crisis in science education masks the sad truth that the vast majority of students are taught science that is utterly irrelevant to their lives and that 'scientists are a major part of the problem; many think that the system is a good system because it produced them'".

CURRICULA

With respect to *curricula*, is it still appropriate to categorize science discoveries and knowledge into the traditional disciplines? Educators, teachers and university professors are known to be conservative. In developing curricula, an open or undercurrent conflict emerges when periods in secondary school science are allocated to physics, chemistry or biology. Traditionally, physics had the lion's share as the dominant science. I wonder how many in the audience with a physics background will shake their heads when it is proclaimed that over the past few decades, biology has replaced physics in dominance or significance. Biology was transformed since the 1953 discovery of the double–helix structure of DNA by Francis Crick and James Watson. Conceiving ways of manipulating those strands of genetic material became known as genetic engineering. This has developed recently into the capacity to clone animals and read entire genetic structures (decoding the human genome). The attention is now directed at the more complicated proteome (all the proteins in an organism). Pursuing fields like molecular biology indicates that scientific studies and research have increasingly become inter–disciplinary in their essence.

From its early days IOSTE was engaged in the Science, Technology and Society (STS) movement but currently, we have also to intensify emphasis on aspects related to values, ethics, and law as extensions of science and technology innovations. Advances in technology, particularly in areas related to genetic and bio–engineering, tinkering with human tissue, developing artificial body parts, and cloning human beings – have challenging implications embodied in the question: Should there be taboos in the pursuit of some kinds of knowledge? Who is in the best position to decide among those responsible for technology, politics and ethics if the cloning of animals to secure spare parts for human organs should be pursued? How can we ensure that technology will be channeled away from destructive uses? Learning from history, it was too late when some nuclear physicists were sorry for their contributions in the development of nuclear bombs. Clearly, underlying the great benefits that can accrue from certain pursuits of knowledge are great potential dangers stemming from diverting new knowledge to "undesirable" ends.

In canvassing views and opinions of scientists, it should be kept in mind that scientists are human beings before being scientists. As such they are not always immune from substantiating research results that side more with the interest of employers and sponsors than with the truth. The white laboratory coat of the scientist does not bestow absolute objectivity and ethical values. Historically, the tobacco and lead paint manufacturers have pursued marketing strategies to prolong their sales as long as possible after the threat of their products to health has been discovered. There are also stories about the pharmaceutical industry using unethical means to postpone marketing a promising but competing drug. As IOSTE promotes global science and technology education, it should contribute to realizing the goals of ensuring that the great power unraveled by scientific and technological discoveries and advances is accompanied with great responsibility.

Let me borrow from "Essential questions" by NSTA president in a recent issue of NSTA Reports. According to Arthur Eisenkraft, the most popular student question is "Will this be on the test?" More often than not, the student is in effect asking: "What is relevant?" or I have no way of determining which facts, principles, or theories are important and would like you to tell me specifically what they are. He goes on to list the following four questions that the curricula should be emphasizing and the student should be asking:

What does it mean? How do we know? Why do we believe? Why should I care?

I will paraphrase or cite from the discussion related to the last question: Why should I care? It addresses the relevance of what a student is learning to the student's life. Some answers to the student include: "This is needed for a later chapter" and "One day this will be useful to you". Most probably the later chapter holds no relevance to the student's life and the other answer is also probably not true. I bet that each of us in this hall can easily select within few minutes several facts or pieces of information and sometimes concepts in his or her discipline that are actually taught in our schools but which cannot be defended in a rigorous test of relevance. We should apply this test as curricula are being developed and assessment is carried out. With the rapidly increasing amount of knowledge and principles, we have to be eclectic. But the particular needs of countries and communities within countries should not be forgotten.

Paul Hurd (2000) in a recent commentary criticizes the science education reform movement in the U.S. The reform, he states, has consisted of simply updating traditional science facts and principles and changing the name of the list to "standards", which represent the nature of science disciplines but not the quality of life. He concludes that "As science teachers we face a host of revolutionary changes in the nature of science and what should be taught for adapting to a rapidly changing society and an Information Age. It has become evident that it will be necessary to reinvent science curricula, both goals and subject matter. The centuries–old process of updating the content of existing courses and fostering a single mode of inquiry are no longer adequate". It is evident that what students learn especially in the years of formal education does not last them long. Their education has to be transformed to address lifetime needs.

"The advent of the personal computer, the Internet and the electronic delivery of information have transformed the world from a manufacturing, physically–based economy to an electronic, knowledge–based economy. Whereas the resources of the physically–based economy are coal, oil and steel, the resources of the new, knowledge–based economy are brainpower and the ability to acquire, deliver and process information effectively". (Merrill Lynch, p. 16). In this new environment, the continuous challenge is for the labor force to upgrade its skills. Computer literacy is commanding a special place in the modern curriculum. Advantaged children are apt to use computers extensively at home. Often, it is the needs of disadvantaged children that have to be met. When schools are provided with computers, for example, does the school or school system schedule the school day in ways that enable students to use computers. Curricula have to embody and accommodate these requirements and trends. One common pitfall in curriculum development is succumbing to pressure of politicians to process products quickly without the benefit of field–testing prior to publication and universal adoption. The problem occasionally becomes worse when the educators themselves become politicians.

TEACHING/LEARNING APPROACHES

Teaching approaches as well as instructional materials should be consistent with the knowledge of *how students learn*. But how do students learn? Are there agreed underlying principles and are there universal approaches that apply to all? We usually recommend finding ways to develop in the students higher–order thinking skills, enabling them to distinguish evidence from propaganda and probability from certainty, engaging them in hands–on learning activities, and monitoring their progress or lack of it through testing. Replicating practices from one country to another, or from school to school within a country, is complicated by a variety of factors a major one of which is the background of the students. We need to find and use methods – instructional and learning – that will address individual differences among students and help them achieve better and become lifelong learners.

Is there one formula to deal with the diversity in the classroom – diverse needs and capabilities, achievement levels, learning styles, and interests? Teachers need assistance and tools to monitor, guide and assess the progress of their students. Learning Information Systems (LIS) have the potential to be used to track student performance, to access resources to supplement instruction, and to exchange ideas with other teachers and professionals. (Merrill Lynch, p. 98). As rates of enrollment at all levels increase, educators are faced with wider range of abilities, multiple learning styles of students, variety of backgrounds and levels of motivation, among other individual differences. All these require increasingly talented teachers capable of adapting their approaches to the varying needs of children. Furthermore, such situations require developing more tools that enable students to work at their own pace. It does also require close observation, diagnosis and interventions, remedial or otherwise.

A school network listed in the Appendix of Merrill Lynch's "The Book of Knowledge" is the SABIS. I have visited one of their schools in Abu–Dhabi about two decades ago and I remember that their approach was heavily computer–based. Their recent Newsletters reflect that the system experiments with video conferencing across schools, and utilizes an accelerated reader program which entails detecting, testing and developing reading skills of all students and attempting to create a lifelong love of reading. The reading program provides thousands of titles with tailor–made, computer–taken, computer–corrected tests that give students immediate feedback. In SABIS' November 1998 Newsletter, it is stated: "Applicants to the school have to have a willingness to work.... Students new to our system sit a series of diagnostic tests in the core subjects and are placed in mixed ability classes. We teach comprehensively, helping all our students to maximize their potential by using unique SABIS methods of teaching. Students are examined regularly and their achievement is evaluated. Any gaps that may have formed are pinpointed by the academic monitoring system. These gaps are filled, before the teaching of new concepts is undertaken. No effort is spared to attain our goal of having every student pass on merit...".

Compare the teaching approaches required in a school adhering to such a philosophy of students' admission to other private schools, which administer extensive tests to decide on admitting even 3 or 4 year olds. If you manage to secure a student population heavily scrutinized prior to admission and selected on the basis of high ability, most students will learn and achieve in spite of the capabilities and performance of the teacher. The teaching approaches in such situations are bound to be different from those in heterogeneous ability groups. There have been many views and theories of how people learn. One of the recent theories (that has bloomed after I changed careers from university teaching) is constructivism – students learn by interpreting messages or information based on previous knowledge. After an interesting discussion related to the interactions of science and culture, Cobern (1995) concludes: "In constructivism, the science education research and curriculum development communities have both a model of learning and a view of knowledge that is authentically sensitive to both culture and science".

A teaching approach that depends upon arousing students' interest and curiosity is the use of discrepant or counterintuitive events in teaching science concepts. These are occurrences or happenings that go counter to what one thinks likely or expects. Tik Liem (1981) compiled a collection of discrepant events and used to have sessions in science teaching conferences and symposia that aroused the interest even of seasoned science educators. To illustrate, the topics include: fountain in a flask, the obedient diver, boil water with cold water, rolling uphill, and are women stronger than men? A study of mine about science misconceptions revolves around a similar principle of trying to identify erroneous notions and the extent of their prevalence among certain groups of students (Za'rour, 1975). Awareness of these should influence the way those concepts are taught.

Appropriate teaching approaches need capable and committed teachers. Probably, teachers do not have much to complain about in Europe and Japan as in the U.S. In America, teacher groups have long taken the position that all teachers should essentially be treated alike. With this attitude, they have resisted merit pay, accountability measures, and differential pay for disciplines in which there is a severe teacher shortage. Under such policies by an education system or Ministry of Education – little recognition or extra remuneration is given to outstanding teachers who put in extra time and effort or who could deliver efficiently and effectively. The policies also discourage potentially good teachers from joining the profession and from trying hard. Thanks in part to the dismal results of the international evaluation activities, changes are taking place in the U.S. Several ideas are being tried to reward top teachers, including a career ladder that would culminate in master teacher status. Many countries would benefit from conscious efforts and interventions to keep excellent teachers in the classroom instead of promoting them to the traditionally better–paying administrative jobs. The change in policies requires teachers' groups to be receptive of career ladders and to subject themselves to periodic re–certification. It also requires them to accept new accountability measures and tougher standards designed to weed out incompetent teachers. One common teachers' complaint, which sounds valid, is the fairness of judging them largely on how well their students perform on standardized tests. A more reliable measure, it is argued, is their students' improvement over time.

Teamwork and peer–learning methods are being increasingly emphasized. They provide chances for students, who lack confidence or are afraid of being wrong and be penalized by the teacher, to express themselves and participate. Besides, students can talk at each other's intellectual level. From another angle, it is important to exploit further the potential of technology–based learning and to study how information technology may affect the ways that teachers and students relate to each other both in the classroom and outside. The only certain thing in information technology is change. This has serious implications in teaching approaches, in emphasizing learning how to learn, and in the need of life–long learning. In order for technology to appeal to children and students, its format has to be highly engaging and interactive. The presence of computers in schools by itself will not revolutionize learning. Information has to be managed and service to pupils improved and customized. Learning Information Systems have the potential of providing tools to improve performance of schools and student learning (Merrill Lynch, p. 14). It seems that the SABIS Schools network is utilizing learning information systems effectively.

There should be ways to share successful practices among schools as well as among teacher education institutions. Sometimes, pockets of excellence within a school do not spread even to the classroom next door. One new idea does not remedy a problem in isolation. For example, a longer school day or more classroom contact is hailed as an appropriate measure to improve performance and achievement. However, without improvement of the methods of teaching and without more effective utilization of this extra time as well as the originally available time, better performance may not be realized or may be slow to come. Efforts should be made to identify good teaching, study it and analyze it, and then support attempts to replicate it. The goal, however, is not to define a blueprint or mold to be embraced by all schools and teachers but to provide a model that was tested and that works effectively.

To conclude this section, the call has been to shift teaching approaches away from lecture, rote memorization and telling students what to think toward active learning, interactions among students, and providing opportunities for students to develop their own concepts. Teaching/learning approaches are always evolving in light of changes in goals, demands, knowledge and educational technology. The challenge is to identify and utilize practices that are very likely to succeed.

ASSESSMENT ASPECTS

Assessment has the potential to monitor and measure achievement/aptitudes, to provide performance feedback to schools and students, and to enlighten education officials about the strengths and weaknesses of their systems of education. How do we assess students to help them realize what is deemed to be important and relevant and to lead them into further learning activities? During my first year of teaching in the now internationally famous school of Choueifat, Lebanon (founders of the SABIS school network referred to earlier), I gave my chemistry students a pop (unannounced) quiz. It was solving a problem, which was included as a solved example in the textbook. I told the students that they could use their books if they so choose and I pretended that I did not know the numbers were exactly the same as in the solved example. The message spread quickly through excitement and signals that the quiz problem is already solved in the book. Students who copied it verbatim got it wrong while most of those who solved it on their own got it right. I wanted to give the students a message that not everything in print is necessarily correct. Although it was an assessment exercise, it was intended more as a teaching approach to transmit a message in open–mindedness dramatically, and this is why it was assigned a negligible score. Galus describes in a recent Commentary in The Science Teacher how she purposely made a mistake in a chemistry demonstration to give a lesson that making mistakes is not foreign to scientific advances.

Sample–based national assessment of student achievement is important to provide information to education officials and other stakeholders about how the system is performing. In particular, it will inform stakeholders about the extent to which standards are being maintained nationally in the specific grades that are involved. It is also important to gather "diagnostic" information, about which objectives are being achieved or not achieved. There is a wealth of information in the results of examinations and other assessment activities that often go untapped and which have potential use in improving quality. Analysis to find out strengths and weaknesses of curricula and courses is a must along with research to find out what could be the contributing factors for differences in performance. For example, a study was commissioned to find out why Minnesota eighth graders performed significantly higher than eighth graders in the rest of the U.S. in the Third International Mathematics and Science Study (TIMMS, 1995). While the U.S. middle school curriculum has generally been described similar to a river a mile wide and an inch deep, the Minnesota seventh and eighth grade science curricula involved fewer topics, which were developed in depth, with focus and coherence. According to the reported study, this pattern in Minnesota curriculum is consistent with instructional practices found in the highest–performing nations in TIMMS. (NSTA Reports, p. 23)

Accountability is important and was often raised during the U.S. presidential election campaign last year. It involves repeated testing to identify changes. It is widely accepted that high stakes tests (assessment with consequences), drives teachers and all concerned to direct their efforts and attention to the tests. In a speech to the American Council on Education on February 18, 2001, Richard Atkinson, the president of the University of California, joined those who oppose the widely used admissions test, SAT I, by recommending discontinuation of its use. He stated that excessive time is used to develop students' test–taking skills and that the overemphasis on the SAT is compromising America's educational system. In such situations, other goals of education are often sacrificed. Testing that underlies accountability of teachers and school systems requires a creatively–crafted assessment program that evaluates students in how they perform tasks that match curriculum goals. I was asked few years ago to comment on a study at the World Bank by an economist who headed a group to evaluate school systems by analyzing end of secondary school official exam questions. My major reservation was that a question or problem may specifically indicate that comprehension and application skills are needed to solve it. However, if the concerned candidates have already been exposed to the solution of closely similar questions or problems in their learning experiences, then that specific question or problem is actually testing recall or recognition and not higher cognitive skills because of the absence of the novelty factor.

CONCLUSION

It is becoming increasingly difficult to delineate what is relevant and what is not in an absolute manner. One can safely assume that a large proportion of the curricula in science does not meet the acid test of relevance. If educational systems are courageous and innovative enough to recreate their curricula to render them truly relevant, they might fail to have them implemented because teachers, administrators, supervisors and assessment specialists cannot respond appropriately and in a timely manner to make the innovations succeed. Another common problem is the inability to secure funds to acquire the required physical resources. Thus, changes take place in small steps and piecemeal. Change has become the major force facing governments and educational systems. One has to learn how to recognize change, adapt to it and acquire the basic tools and techniques to deal with it in ways that lead to understanding and controlling it rather than be devastated by it. For the time being, information technology and learning information systems have become the major tools to pursue knowledge and to learn continuously. In this context, relevance is not acquiring a new computer but in being able to use it effectively and to grow with developments in the underlying technology. One cannot ensure that additional resources acquired by a school system will be used effectively in the absence of appropriate organizational and incentive structures. The Internet has become the world's greatest library but everybody involved in education – at home, school or work – will have to be able to use it effectively and efficiently.

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Innovative Methods to Guarantee Science and Technology Education for All

Zafra M. Lerman, *zafral@aol.com*
Gregory A. Neul, *GreggNeul@aol.com*
Keith Kostecka, *kkostecka@aol.com*
Marcelo Caplan, *micaplan@prodigy.net,*
Institute for Science Education and Science Communication,
Columbia College Chicago, USA

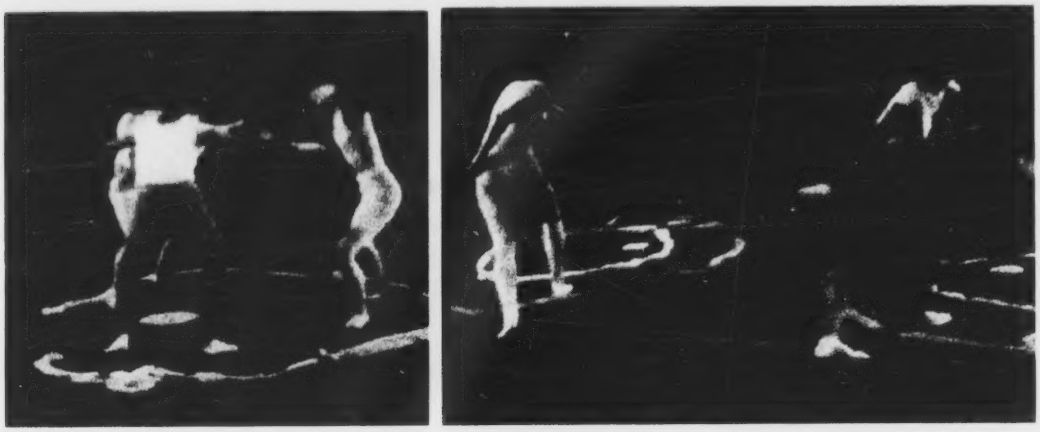
The population of the world recently surpassed the six billion mark, and it continues to increase exponentially, a growth only matched by our scientific and technological advances. It is essential to develop alternative methods for teaching science, mathematics and technology to address the needs of the growing population. In order to guarantee science, mathematics and technology education for all, the Institute for Science Education and Science Communication ("Science Institute") has developed a curriculum that can be adapted to meet the educational needs of the culturally and economically diverse global population.

Over the past twenty-four years, the Science Institute has developed a unique and highly successful method of teaching science to non-scientists that integrates science and mathematics with art, music, drama, dance, sports, and cultural backgrounds (Lerman, 1986a; Lerman, 1986b). These methods have already been adopted by many institutions in Chicago, throughout the U.S., and around the world, in settings ranging from the formal to the informal, and from elementary school to university levels. Only by developing different methods of teaching science, mathematics and technology, and by cultivating critical thinking instead of relying on rote memorization, will we be able to avoid forming a class society that will be divided — not by royalty — but by knowledge of science, mathematics and technology.

These alternative methods of teaching are complimented by alternative methods of assessment. Students can demonstrate their knowledge in science, mathematics and technology using the media of their choice, such as art (Hoffmann and Torrence: 1993), music, dance, drama, animation, sports, and interactive multimedia. The results have been varied and impressive. For example, a music major's song about chemical reactions in the brain, depression, and antidepressant drugs has received national acclaim (see figure 1).

Figure 1: "Chemistry Blues" song written and performed by Peter Perks, a music major, to explain in his chemistry class the action of antidepressant drugs in the brain.

Abstract scientific concepts have been made concrete through painting and sculpture. Other students choreographed and performed a dance representing the separation and combination of DNA during mitosis (see figures 2 and 3). And those star–crossed lovers, sodium and chlorine, have been immortalized on videotape in a drama written, acted, and filmed by Columbia College students, as a mock Shakespearean tragedy ala Romeo and Juliet, with apologies to W. Shakespeare. Sodium, in the role of Romeo, gives his electron to Chorine (in the role of Juliet) to make her his wife and, subsequently, forming table salt. However, because this is a Shakespearean tragedy, Water takes over the duo and their bond breaks ("For never was a story more dark and glum, than that of Chlorine and her Sodium").



Figures 2 and 3: Images from "Mitosis: A Dance" choreographed by Dia Bubalo, showing the activity of DNA before and after the cell nucleus splits into two.

Students in the Science Institute's "Crime Lab Chemistry" class use the Science Institute's state-of-the-art analytical laboratory [including, in part gas chromatography–mass spectrometry (GC/MS), infrared spectrophotometer (IR), ultraviolet/visible light spectrophotometer (UV/Vis), and atomic absorption spectroscopy (AAS)] funded by the National Science Foundation. Students learn to solve a crime through the application of science. An art student in this class demonstrated in a poster everything she had to examine and test in order to solve the crime: body fluid, blood, lipstick, arson, fibers, fingerprints, DNA, chemicals, etc. (see figure 4).

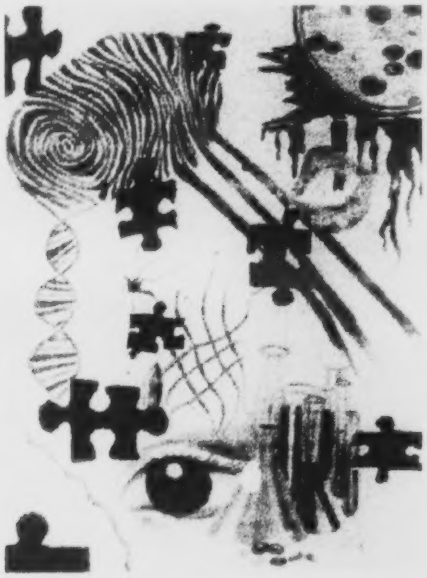


Figure 4: "Forensics" poster by Teresa Crout, depicting the various experiments and tests she needed to perform in order to solve the crime.

Students retain their knowledge of science many years after they graduate, and they attribute this accomplishment to the fact that they used art, music, dance and drama to internalize the learning process (Kostecka, Lerman and Angelos, 1996; Lerman, 2000; Lerman, 2001).

Howard Gardner (from Harvard University) developed the Theory of the Multiple Intelligences (Gardner, 1993). He explains that teaching is usually directed toward the logic intelligence, and that people such as dancer Martha Graham, musician Stravinsky, and artist Pablo Picasso all have "talents." According to Gardner's Theory, what these individuals have is different intelligences, and if we adjust our teaching to fit "The Multiple Intelligences," we will be able to teach anything to anybody. Thus, Howard Gardner has successfully put into educational terms the experiences of the Science Institute.

The success of these methods developed in the Science Institute prompted the National Science Foundation (NSF) to award $250,000 to Columbia College, Princeton

University and Indiana University in order to develop a joint environmental science curriculum which will adopt within the three institutions the teaching methods developed at the Science Institute at Columbia College for non–science majors. The rationale behind this collaboration is that a curriculum designed to fit the three very different type of institutions should produce a model curriculum readily adaptable for almost any institution of higher education, traditional or non–traditional: Columbia College is an urban, four–year, open–admissions college with a high proportion of underprivileged, low–income, inner–city students; Indiana University is a large state school; and Princeton University is a private university which accepts only the top five percent of high school students (Lerman: 1997). This curriculum, considered by the NSF as its "flagship project" was adopted by many universities in the U.S. and abroad. These courses which integrate science, mathematics and technology with the arts have made it possible to make science, mathematics and technology education accessible to all, independent of race, gender, economic background, and cultural backgrounds.

With assistance from the National Science Foundation, the Science Institute has developed a Science Visualization and Communications Laboratory, which allows students to explore new technologies in preparing and presenting their projects. 2D and 3D animations were employed in presenting scientific concepts such as the chemical bond, acid rain, depletion of the ozone layer, and fission reactions (see figures 5 and 6).

Scientific accuracy is fundamental to this approach, and is never sacrificed.

Figures 5 and 6: Images from Todd Ripplinger's "Little Boy", demonstrating a fission reaction through computer animation.

Unfortunately, these innovative methods are sometimes misused and the resultant projects do not reflect objective, accurate science. It is therefore paramount to understand how to utilize the methods developed at the Science Institute in teaching, learning and assessing science, technology and mathematics, without sacrificing the accuracy and objectivity for which science, mathematics and technology stand.

Additional funding from the National Science Foundation, Joyce Foundation, Illinois State Board of Education, and the Chicago Annenberg Challenge was provided to Columbia College's Science Institute to introduce these methods within the Chicago

Public Schools through teacher workshops, parent workshops, and by bringing children to Columbia College for "A Day of Science." For these inner–city children (many of whom are underprivileged), the opportunity to "be a scientist" in a lab for an entire day is the first time most of them have heard about university education. During the years, many of these children have chosen to apply to high schools with emphasis in science, technology and mathematics, and many of them went on to pursue careers in these fields.

The Chicago Public School system is the third largest public school system in the U.S.; its demographic and economic diversity is representative of the diverse population of America. During the past eleven years, the Science Institute has served approximately 600 teachers who, in turn, teach tens of thousands of students per year. This introduction of the Science Institute's methods into the Chicago Public School system has led to a dramatic increase in the science level of teachers and students as well as an increase in the amount of time teachers devote to science in the classroom. Chicago Public Schools teachers who participate in Science Institute workshops and employ these methods in their classes have reported that seventh and eighth grade children (who previously would "never come close to the chemistry lab") now prefer to stay after school in chemistry clubs, rather than attending gym class. Many of these students have chosen to attend high schools which specialize in science and mathematics — which never happened before in these teachers' experience. The graphs (shown in figures 7 and 8) show the remarkable increase of teachers' classroom practices after the workshops in (a) conducting science experiment daily or almost every day and (b) discussing with their students science careers weekly, compared to practices before the workshop and compared to national averages.

These methods have proven particularly effective at what our experience demonstrates are the crucial ages: the fifth grade (before children enter middle school), and the eighth grade (before children enter high school). The graph in Figure 9 represents the achievement of students whose teachers attended our workshops, compared to those of students in the same school whose teachers did not attend our workshops.

In order to assure the best science, mathematics and technology education for all, the Science Institute proposes to expand the model it has developed in order to meet the educational needs of the ever–growing world population. It is the tenet of the Science Institute that free and equal access to science, mathematics and technology education is a basic human right that belongs to all.

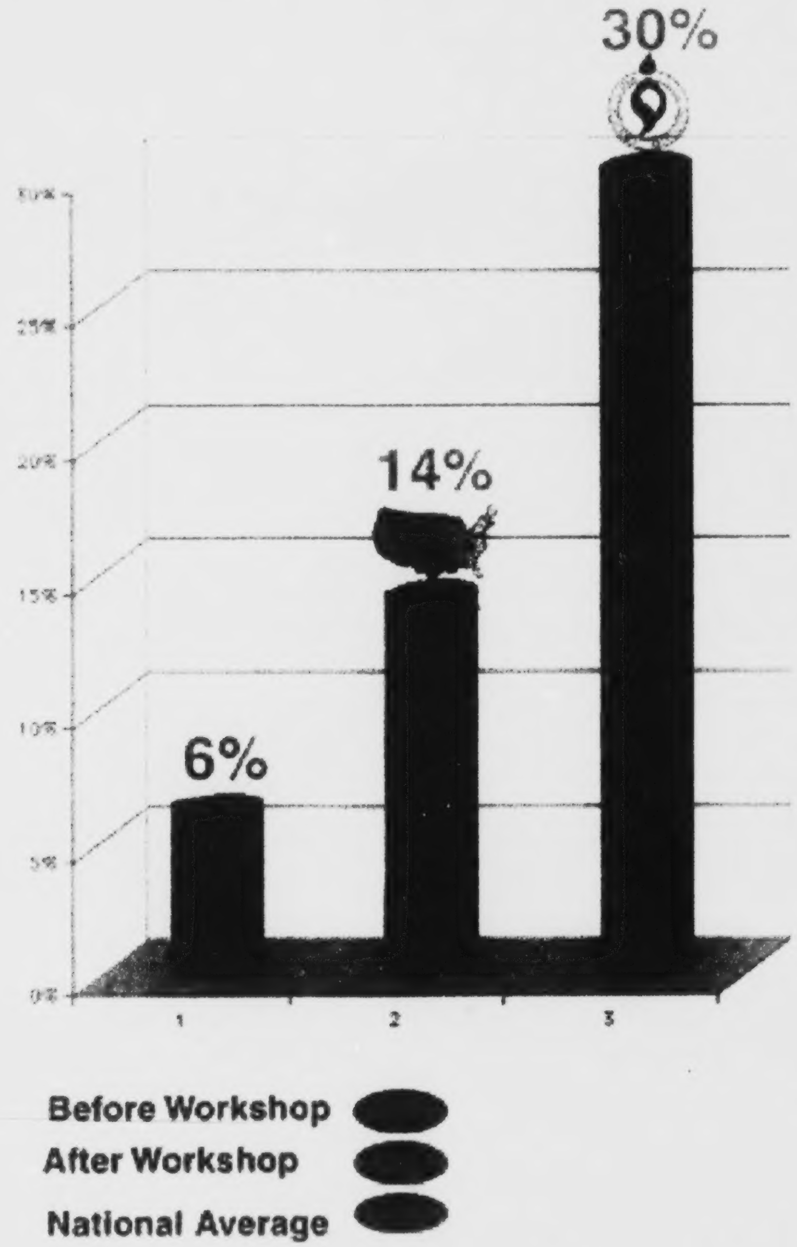


Figure 7: Graph representing the effect of Science Institute workshops on teachers who have students perform science experiments daily or almost every day, compared to practices before the workshop and compared to national averages.

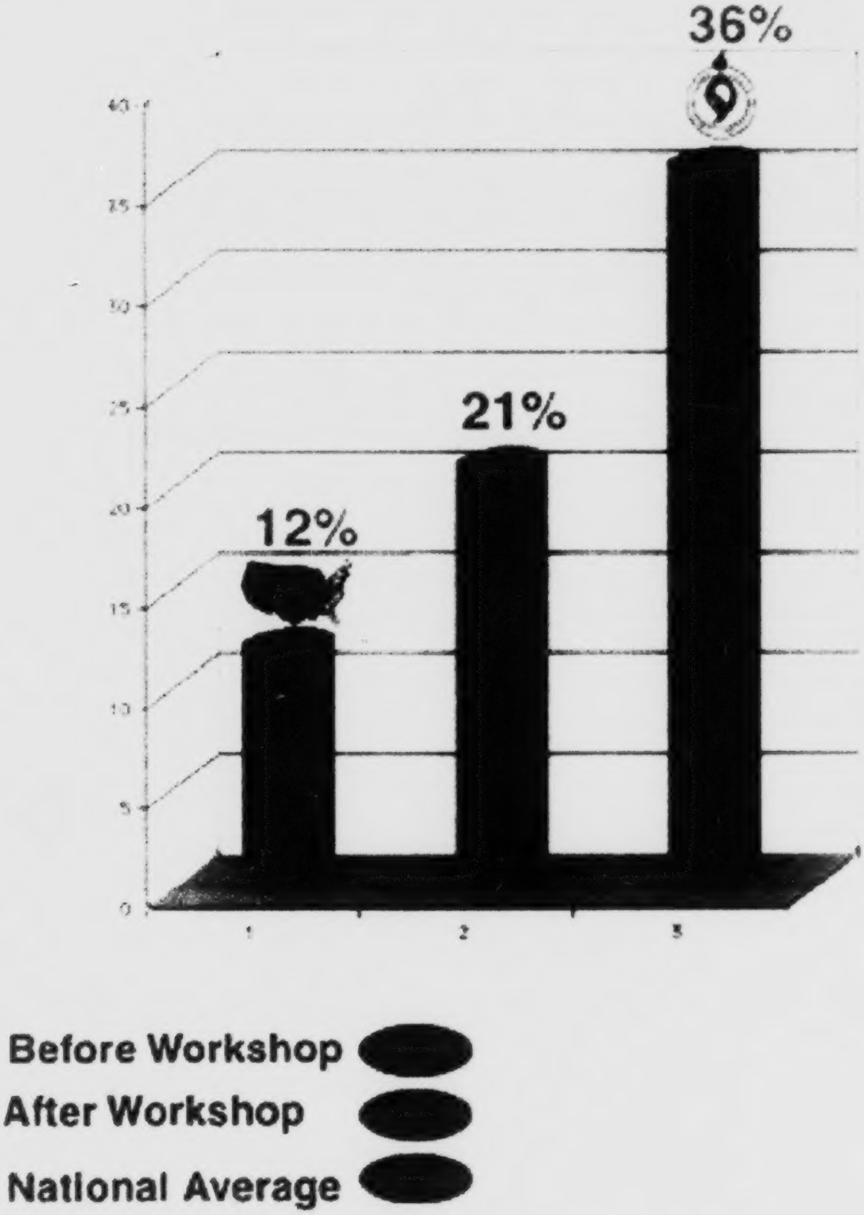


Figure 8: Graph representing the effect of Science Institute workshops on teachers in discussing with their students career opportunities in science fields each week, compared to practices before the workshop and compared to national averages.

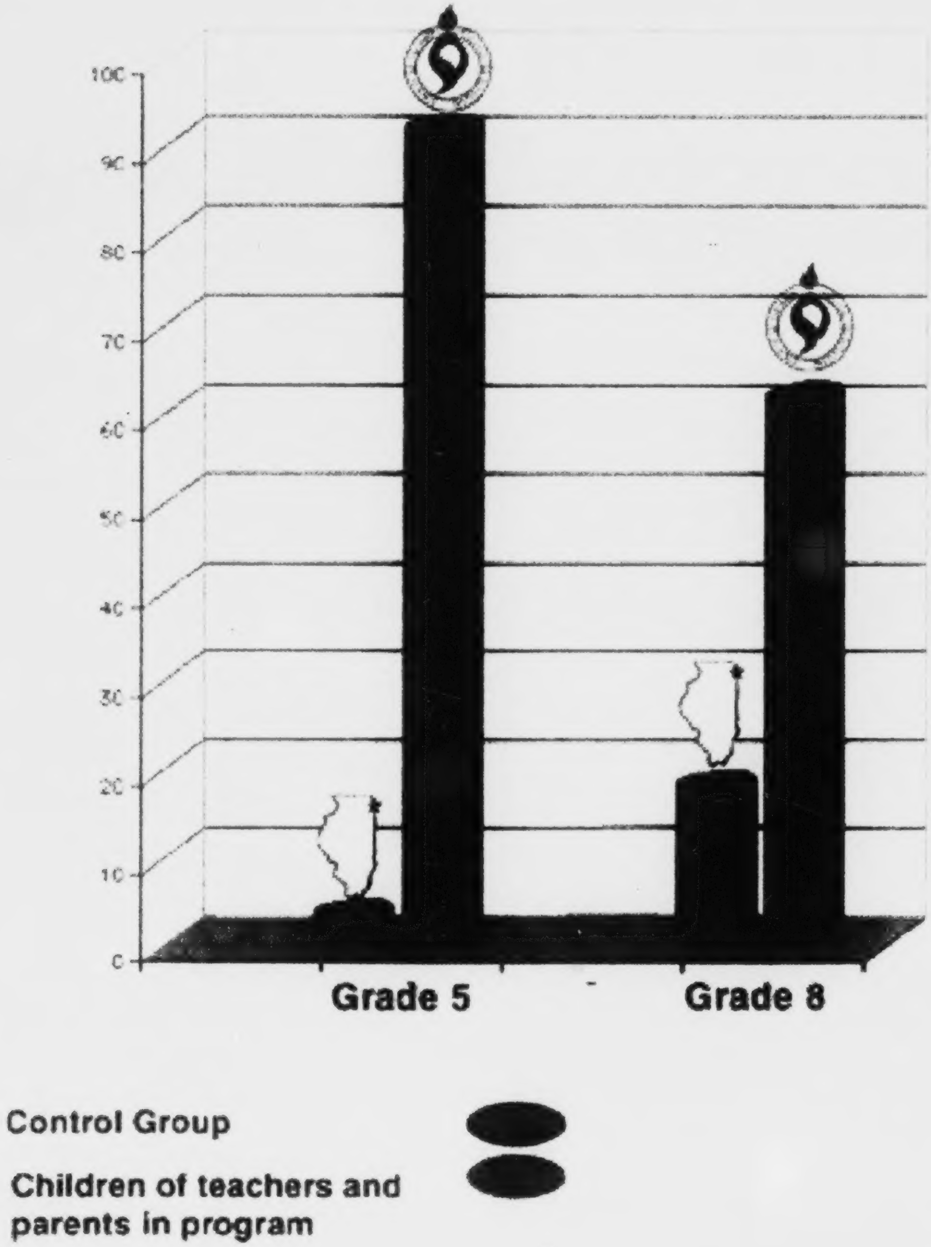


Figure 9: Graph representing achievement of students whose teachers attended our workshops, compared to those of students in the same school whose teachers did not attend our workshops.

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Integrating Industrial Chemistry into the Israeli Syllabus: A Science,Technology, and Society Approach to Chemistry Studies

M. Kesner and A. Hofstein,
The Weizmann Institute of Science, Israel,
ntkesner@wisemail.weizmann.ac.il

BACKGROUND

In Israel a course in industrial chemistry is offered for high school students who opted to major in chemistry. This course is an integral part of the chemistry curriculum and combines scientific, technological, environmental, and societal applications (STS) in the context of the chemical industry. It was planned to be taught after the general, basic chemistry course and to be related, as much as possible, to the students' scientific background. The case study method was adapted for developing this course. This method enabled us to describe real situations and actual problems that exist in the Israel chemical industry.

Two different industrial chemistry case studies were developed using the same basic approach, including the same general components, providing an opportunity for introducing relevant issues to students. One case study deals with fertilizers* and another with bromine products based on salts from the Dead Sea.** Key concepts of industrial chemistry as well as their relationship to other related disciplines are presented through these case studies (1).

Based on research results (2), clearly in order to teach effectively the industrial chemistry topics, it is vital to supply teachers with basic background knowledge, help them to cope with their natural reluctance to teach this interdisciplinary subject, and train them to use varied teaching methods. In addition we suggest that teachers' training courses involve teachers with a wide spectrum of instructional techniques and with planning new strategies for implementing chemistry in the classroom (3). Qualitative research on 12th grade students participating these case studies led to the following major conclusions:

- ☐ Students were more aware of the relevance of chemistry to their immediate surroundings and daily life.
- ☐ To these students chemistry is now less theoretical and more an applied science.

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* First edition in 1988, updated second edition in 1999.

** First edition in 1990, updated second edition in 2000.

Development of Industrial Chemistry Case Studies

The process of developing the new teaching units entailed the following steps:

1. Selecting a plant that would serve as the basis for the industrial case study. The chemical plant should have importance to the local residents and preferably use local raw materials; the industry should be willing to cooperate in the project and also be financially solvent. The case studies should be based on industries from different regions. Thus, based on geographical considerations, teachers may choose the case study most relevant to their students.
2. Gathering relevant data, by visiting the facilities and interviewing various employees in different positions. This is necessary because there is no readily available up–to–date information that can be directly used for developing the teaching unit.
3. Selecting topics and concepts relevant to the teaching unit, taking into consideration the students' chemistry backgrounds.
4. Designing the unit using a flow chart that organizes the main topics, followed by a detailed presentation of the concepts and the contents of each topic.
5. Developing the subject matter into smaller topics.

The two case studies were developed taking into consideration the general goals mentioned earlier. More specifically, they were both planned according to similar objectives aimed at emphasizing the inseparable links between science, technology, environment, and society, while giving the students the following skills and knowledge:

- The special language used in industry regarding basic technology, economy, and industrial processes;
- The differences between a laboratory and an industrial process and the scaling–up steps needed for industrial production design;
- The dynamic nature of industry;
- Information regarding economical, environmental, and technological problems which face a chemical industry;
- The connection between the chemical industry and social and political issues, including moral dilemmas.

Table 1 presents some topics and concepts included in both updated case studies

The updated case studies emphasize the development of the student as an independent thinker and confront him with real problems. For example the students are asked to cope with environmental dilemas, to think about advantages and disadvantages concerning issues such as the use of products, industrial processes, construction materials, and separation techniques. They have to think about the pros and cons of certain issues, to suggest solutions or to choose a compromised solution based on scientific data. Some of the activities are based on group work and this encourages the students to have discussions, compare different solutions, and evaluate information.

Chemical concepts	*Technological aspects*	*Ecological aspects*	*Other aspects (societal)*
Chemical properties	R& D	Green chemistry	Location of plant
	Industrial processes	Hazards and risks	Economical aspects
Reaction: reactants &	Scaling up	Toxicity	(profitability, supply
products & conditions	Pilot plant	Toxic wastes	and demand,
	Operation units	Treatment of wastes	production costs etc.)
Bonding & structure	Construction material	Disposal of wastes	Manpower considerations
Solvents & solutions	Batch or continuous	Accidents prevention	Licensing
Oxidation–reduction	Flow chart		Patents
Acid–bases	Separation techniques	Environmental	Quality control
Stoichiometry	Production facilities	legislation	Total quality management
Equilibrium	Conversion & yield	and standards	Marketing & sales
Termochemistry	Energy resources	Safety rules	Political aspects
Thermodynamics	Energy saving	Safe transportation	
Free energy	Storage techniques	Recycling	
Kinetics	Transportation facilities	Recovery	
Catalysts		Air pollution	
		Water pollution	
		Earth contamination	
		Safety equipment	
		Safe storage	
		Purity of raw materials and products	

Implementation of Industrial Case Studies

Teaching industrial chemistry based on the goals described must be accompanied by intensive and comprehensive in–service training of chemistry teachers. This is based on an evaluation of our inservice training courses. The research was done by pre and post questionnaires that provided background information about the teachers as well as their problems and feelings regarding teaching the subject of industry and their expectations from the course. When asked about their feelings regarding teaching the subject of industry, teachers said: "We feel insecure because we have no background in this field", "It is hard to teach about industry", "We are afraid that it will be boring for the students", "It demands a completely different way of thinking" and so on.

We also found that the traditional training of chemistry teachers at universities or teacher training colleges hardly touches upon the applications of chemistry in general, and those of industrial chemistry, in particular. Even in the rare cases when teachers have an appropriate background, up–to–date information on industrial chemistry is not readily available. For this reason, many teachers do not feel competent to handle the many facets that such an interdisciplinary program touches upon. In addition, most teachers regard their major task as to supply knowledge in the cognitive domain, namely, teaching chemistry concepts. We have taken into consideration the results when planning the courses (3).

Qualitative research results

Qualitative research contributes to:

☐ Formative evaluation

☐ Summarizing evaluation, especially in the affective domain.

We used varied, tools and techniques such as open–handed questionnaires given to the students, video taping of the class during discussions and peer teaching activity as well as interviewing students.

Some of the most important conclusions are as follows:

☐ Students studying the industrial case studies were more aware than other students of the relevance of chemistry to their immediate surroundings and daily life.

☐ Students studying the industrial case studies were more aware than other students that chemistry is an applied science.

☐ Students prefer to work in groups and to deal with problems that demand a high level of thinking.

☐ Relevance is achieved through using examples of substances and materials that are part of the students' daily life or immediate surroundings, such as plastic materials, clothing, swimming pool disinfectants, and flame retardants etc.

☐ Discussions regarding the application of chemistry principles to industry contributes to viewing chemistry as part of real life.

☐ Presentation of interdisciplinary problems to the students demanded the use of knowledge from different domains in chemistry and thus overcomes the "drawers" problem.

Summary and Implications

In all countries, there is a need to open a window to the world outside school. The way to do so is to present chemistry not only as a body of knowledge, but as an applied and relevant subject that influences the students' personal lives, as well as affects the society in which they live (4,5). There is no doubt that the chemical industry can provide an interesting and useful opportunity for introducing relevant issues to high school students)6). Basic concepts of industrial chemistry as well as its interrelationships with other related and relevant disciplines can be presented through various case studies. The guidelines in planning such a course are similar in most countries, although the actual industries described and details of the production methods obviously vary from place to place. In different countries chemical industries uses different raw materials for the production of various materials; however, a similar interdisciplinary approach can be used to enable the student to understand the overall concept of the industrial world. The principles of chemistry should therefore be combined with problems of technology, economics, and environment.

In this study it was found that industrial chemistry case studies helped in providing the student with a relevant portrayal of chemistry in general with emphasis on industrial applications, and of their chemistry studies in particular.

The results of this work should not be limited only to the development of the teaching units. To successfully implement the teaching units in the classroom, proper training of the teachers is essential. Our findings also suggest that teachers' training should have an interdisciplinary approach and appropriate teaching methods. This training should present various teaching methods, should show the relationships and the relevance to other related disciplines, demonstrate how previously acquired chemistry knowledge is applied, and motivate students to think independently and debate efectively about issues.

In conclusion, the findings of this work support the notion that studies in industrial chemistry should be an integral part of the chemistry curriculum if we want to make chemistry more relevant and applicable to the student.

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Science for All: Making Science Accessible to All

Michaella Kadury–Slezak and Amos Dreyfus,
The Hebrew University of Jerusalem, Israel,
dreyfus@agri.huji.ac.il

Biology is an important and compulsory subject at the Junior High School level in Israel, as a part of the subject "Science and Technology", in particular since most students will not study biology beyond Junior High School or the first grade of Upper High school. Being a compulsory subject matter, as opposed to optional ones (students may choose not to take it) or "selective" (the system selects the students according to some criteria), subject matters, biology must be taught in ways which are suitable to most of the students.

One of the problems is that biology is a quantitative subject. In some cases, quantitative aspects (i.e., mathematical concepts or principles) appear to be essential to the understanding of the biological phenomena. The size and direction of the influence of the independent variable can be predicted only by means of mathematical computations, using formulas and various mathematical tools. The definition of the variables (such as ratio, percentage, concentration, etc) actually includes mathematical concepts. In fact, such biological principles, labelled in this research "biological principles with intrinsic quantitative aspects", cannot be taught only qualitatively. However, since a majority of pupils find it difficult to understand and to use mathematical tools (*Heid,1995*), mathematics can hardly be considered to be a reasonable and efficient basis for the meaningful learning of such biological principles, and indeed, such a method has been very often found to fail. In addition ,students are afraid from mathematics (Zaslavsky,1994).

A possible solution to this problem is proposed here, namely, to teach quantitative biological principles without using formal mathematical tools, by reversing the sequence. The idea is that instead of taking the mathematic knowledge as a starting point, students' development of a meaningful perception of the nature of the quantitative principle to be learned, should come before they are required to perform computations by means of formal mathematical tools.

The strategy suggested here is of a constructivist type, based on the students' previous knowledge: The topic of learning is a "biological phenomenon with intrinsic quantitative aspects". At the first stages, the students try to deal with the biological phenomenon by using their existing knowledge, on which the process of meaningful learning will be built (Ausubel,1968; Vosniadou and Ioannides,1998). The biological context is expected to be more concrete to the students than mathematical concepts (*Shayer,1987*).

The aim of this research was to observe the learning behaviour of 9th grade students taught by the suggested method, when confronted with "biological principles with intrinsic quantitative aspects", i.e.,:

1) To identify the cognitive difficulties encountered by the students ;

2) To see if the students develop a meaningful understanding of quantitative principles, even before being taught to perform the relevant computations by means of formal mathematical tools;

3) In the case of a positive answer to question 2, to see if the conceptual change mentioned in (2) does ultimately improve the students'meaningful understanding and use of the related mathematical tools.

Two learning modules were designed, to teach two "biological principles with intrinsic quantitative aspects. The first module – "Inward and outward motion of matter or heat in organisms", deals with the influence of the ratio between the surface and the volume (the quantitative principle) on the inward and outward motion of matter or heat in multi–or mono–cellular organisms. The second module – "Nutrition: Percentages of water and dry materiel in food and organisms", deals with the caloric value of food (the subject which contains a quantitative principle).

The proposed teaching sequence in both modules includes three stages:

1. At the first stage, called *"The stage of conceptual change"*, the students perform a few experiments intended to lead to conceptual change and to the construction of a mental conception of the quantitative principles without using computations. The experiments are simple and their concrete results are directly perceived by the students. While performing these experiments, the students actually deal with the quantitative principles without mathematical computations and/or formal mathematical tools.
2. At the second stage, that of *"computing"*, the students learn to use mathematical tools to solve *biological* problems. The main characteristic of this stage is that the students use mathematical tools only when they already understand the quantitative principle which underlies the biological phenomenon under study.
3. At the the third stage, the stage of *"Application"*, the students are expected to apply their knowledge of the quantitative principle and of the computing tools, to new situations, some of them abstract (using symbols instead of concrete entities or precise dimensions).

The experimental sample

Four junior high school classes (about 100 students, 15 years old, with 4 teachers), studied the first module, and three similar classes (about 60 students with 3 teachers) studied the second. Altogether, the sample included 6 classes and only 5 teachers, because one class studied both modules. The sample, as well as the comparison classes, came from schools which are not characterised by any special learning difficulties, and its heterogeneity was similar to that which may be found in any Junior High School in any developed area in the country.

Evaluation instruments

Classroom observations were used as the main tool for the uncovering of *student's cognitive difficulties*. The lessons were audio–recorded and the scripts of the lessons provided additional information about the difficulties encountered by the students.

Also, a sample of students was interviewed (low, average and high achievers) during the learning period.

The same tools were used to observe the *development of the concepts* of the students and the process of conceptual change.

Teachers' and students' opinions regarding the teaching method: At the end of the learning period, all the teachers and a sample of students were interviewed about their opinions concerning the method, and about the difficulties they had been confronted with.

Quantitative evaluation

A multiple–choice test was designed for each module to check the *understanding of biological and quantitative principles*.

In some questions, the students were requested to justify their answers. The test consisted of three parts:

Part A) Understanding of the principle without computations(computation was actually made impossible);

Part B) Techniques of mathematical computations;

Part C) Computations of the size and direction of the influence of an independent variable on the dependent one. In this part, the student had to select the appropriate mathematical tools, and to use them correctly to solve a little problem.

MAIN RESULTS

QUALITATIVE RESULTS

The student's cognitive difficulties:

The types of specific difficulties encountered by the students during the various stages of the modules, and uncovered in this study, are delineated below:

DIFFICULTIES AT THE STAGE OF "CONCEPTUAL CHANGE"

1. Difficulties due to a lack of scientific background

Students often didn't feel able to cope with a problem, because they felt the need to develop first a concrete perception of the nature of some scientific concept, even when the concept itself was not directly essential to the solution of the problem. Answers of the type "Never mind now what X looks like, you will learn that when you are older" did not satisfy them, and they actually refused to go ahead with the learning activity without obtaining a satisfying perception of the concept. They appeared to be unable or unwilling to reason on the basis of an abstract entity, even when the precise features of such an entity had no role whatsoever in the reasoning process.

For example, while the class studied food absorption by one–cell organisms (any protista), a discussion flared up about the details of the function of one–cell organisms. Such details were absolutely irrelevant to the solution of the problem, which referred only to the size of the organisms. However, the students requested "satisfying" details about the life of protista, details which they did not need, and actually did not use in the solution of the problem.

The student's refusal to continue the lesson until getting "irrelevant" details, showed that the importance of the science background was not always because of it's direct relevance, but because the students did not easily reason on the basis of an abstract – to them – scientific entity.

Conflicts between students' preconceptions and the logical conclusions of experiments.

Students often rejected anti–intuitive conclusions from experiments, which contradicted their naive existing conceptions (*Champagne et al,1983*). When doing so, they prevented the occurrence of a planned cognitive conflict, since such a conflict was expected to arise from the discrepancy between the implications of empirical findings and students' previous knowledge. The important fact in such cases was not that misconceptions prevent understanding of formal scientific explanations, *but that even when confronted with empirical findings which explicitly contradict their views, students may reject the findings and tend to stick to their existing naïve interpretation of facts.*

DIFFICULTIES IN MAKING INFERENCES FROM EXPERIMENTAL DATA.

In each module, the main difficulty was that at some stages, in spite of being apprently "shown" what had happened in an experiment, the students failed to see what could be inferred from the experiment.

For example, when a block of agar was divided into small cubes, it became very clear that the surface of agar in contact with the external solution was much larger than in the whole block. However, the students did not infer from their direct observations, that *each small cube* had a bigger surface to volume ratio (more contact surface relative to the volume). The identification by the teacher of such obstacles to further learning was obviously crucial. Their treatment required specifically focussed teaching activities (in this case we used a so–called 3×3×3 cm "Hungarian cube", made of 27 small cubes of $1cm^3$ each, the faces of which are coloured in different colours). However, since such activities overcame the obstacle, it can be said that difficulties in learning may not always derive from students' inability to understand concepts or to perform some task, but *from unjustified expectations of teachers, who are unaware of the complexity of some intermediary cognitive task they require from the students.*

DIFFICULTIES AT THE SECOND STAGE (COMPUTATIONS)

1. Difficulties in understanding the meaning of a mathematical operation

The idea of "Ratio" is an abstract quantitative conception that is not dependent on any specific reality. While studying the modules at the stage of "conceptual change", the students had reached a suitable perception of the meaning of the concept, in *reference to concrete situations*, e.g., "how many units of surface for one cube". However, when students learned to compute ratios between values, it appeared that some cognitive steps were not spontaneous in their mind, and could not be taken for granted by the teachers. When explaining the meaning of the mathematical operation they used to compute ratios, namely, a division ("something divided by something"), the students relied on mechanical, meaningless interpretations of the results of the operation such as "the surface is 3 times bigger than the volume".

In the other module, even when the students had developed a suitable understanding of the concept of percentage, they were often *unable to explain the relation between the mathematical operations and the concept itself.*

At the third stage, when applying the biological–quantitative principles to new situations, many students found it *difficult to cope with symbolic situations, which do not refer to specific concrete examples and precisely stated dimensions* ("how can I calculate if I don't know how much it is, let us try first with 2 ...").

This student's tendency to prefer situations of which every component was concrete and understood, surfaced also when they refused to work with shortcut formulae, that eliminate the need for several computations, but the meaning of which cannot be directly perceived (the surface to volume ratio of a cube can be computed rapidly by using the formula 6/a, where "a" is the length of the side. The students did not like the idea and preferred the lengthy computations of surface, volume and ratio, every step of which they felt they understood).

THE DEVELOPMENT OF STUDENTS' CONCEPTIONS

At the beginning, the student held naive–intuitive conceptions of the biological phenomenon. These conceptions, based on the students' personal perception and experience were, or were not, consistent with the scientific view *(Stavy and Tirosh,1996; Lewis and Linn, 1994).* The observed phenomena were often interpreted erroneously (e.g., when more particles of materials penetrate the organism in a given period, it is because the velocity of the particles is greater).

Then, while performing some activities focussed on the diagnosed difficulties, the students got the opportunity to assess the meaning and implications of their naive conceptions. The students' ideas, expressed in their own words, showed then that they had built correct interpretations of some concrete events and were able to use meaningfully the central mathematical principle, although they didn't use formal terms such as "ratio" (for example, they said "there are more sides to each cube") and used no mathematical tools.

Eventually, the successful students' responses showed that they had abandoned their preconceptions and constructed more scientific ones. They were less dependent on specific concrete events, and were able to apply the principles they had learned to explain relevant biological phenomenon and then to apply these principles to symbolic situations and even to formulate the principle in terms of symbols (see table 1 for a short example of such development).

Teachers' and students' opinions regarding the teaching method and the modules:

All the *teachers* mentioned that adapting examples to the students' experience had contributed to their understanding of the subject. Also, the teachers claimed that integrating biology and mathematics had contributed to the students' understanding of the biological and quantitative components of the phenomena under study. They thought that, although already at the end of the first stage (non–mathematical), the students had understood the principles which underlie *the biological phenomenon, after the second stage (computations), the biological phenomenon had gained a new "reality " in the mind of the students.* In their views, the three–stage gradual introduction of mathematics had also reduced mathematics anxiety.

The interviewed *students* themselves all claimed that they had reached a sound understanding of the main ideas before the computation stage (the second stage). They said that although they were "scared" of mathematics, they understood that it was impossible to ignore the quantitative aspects of biology, and also that mathematics were essential to "see the whole picture".

QUANTITATIVE RESULTS

For reasons of space, these results will not be presented here in detail. Let us only stress that the "post" study achievements of the experimental classes were significantly higher than the pre ones, and than those of the control classes, and most of them remained stable also after half a year. As for formal reasoning abilities, they were not an obstacle to the learning of the modules.

SUMMARY

Basically, the research hypotheses were confirmed:

1. The students achieved a meaningful understanding of the quantitative biological principles, even before performing computations and using mathematical tools. In other words, mathematical skills were not a necessary "gateway" to the understanding of such biological principles. It would follow therefore that, in spite of their "intrinsic quantitative apsects", the biological principles of the type referred to in this work *can be taught meaningfully without relying on formal mathematical skills.*
2. The students ultimately improved their understanding of relevant mathematical con-

cepts (ratio, percentage) and became able to define them in their own words, at least while referring to concrete situations. They learned to use mathematical tools only after understanding their purpose.

3. Most of the students progressed from a state of naïve and mostly erroneous understanding of the biological phenomena, to a stage where they were able to explain the phenomena on the basis of some mathematical principle.
4. According to the students' and teachers' testimony, even if mathematical tools were not the gateway to the understanding of the biological concepts and principles, their use enhanced the students' perception of the "reality" of those concepts and principles.
5. The teachers' opinions about the method and about the modules, were positive and quite similar in all the experimental classes. However, the follow up of the junior high school students' efforts to cope with biological quntitative phenomena, showed that the success of the method depended on the following:

- For the student, dealing with the biological phenomenon of the type described here, requires mastery of a) aspects of the scientific background, b) mathematical skills and understandings, and c) various cognitive skills (logical and critical thinking, etc.). The planning of the teaching method and sequence must take all these aspects into consideration, as well as various affective aspects of the learning situation (mathematics anxiety, refusal to accept anti–intuitive conclusions, etc.);
- The students tend to prefer to deal with concrete entities and situations, and may refuse to reason on the basis of abstract entities or situations. They may feel the need to construct a concrete mental image of such entities, before agreeing to use it in their reasoning, or before asking relevant questions or expressing opinions about them. As a corollary, as long as the students rely on their previous naive knowledge, they reason on the basis of something which they perceive as real and intelligible, and therefore become actively involved in the process of learning (asking questions, etc.). When switching to "teachers" knowledge, the students may lose the feeling of coping with real and undestood entities. They may become passive, or even refuse to learn and to accept the new knowledge.

  The students' stubbornness to stick to their concrete and, in their view, logical, perceptions of scientific or mathematical concepts or principles may bring about a refusal to adopt conclusions from experiments ("it's impossible"). In such cases, the students may not collaborate with the teacher in the learning process. As suggested by Posner and his colleagues (1982) the part played by *plausibility* in the construction of new (to the learner) concepts may be crucial;
- When student display difficulties in understanding the quantitative relations between variables, it is important to diagnose which are the quantitative concepts that are misunderstood (ratio, percentage, concentration). The teaching activity must then concentrate on the concretisation of these concepts by means of relevant

illustrative examples and experiments, so as to enable the student to construct an accurate perception of the concept, in relation to concrete situations. Students' talk enables the teacher to follow the process of concept development;

- Even when the students understand a biological phenomenon, not all of it's components may be concrete to them. Many entities and situations in biology are abstract. It is important to identifiy the concrete components of the biological phenomenon under study, so as to enable the students, already at the first stages, to participate actively in the process of learning;
- A critical situation during the learning process was diagnosed, when the link between experimental results and illustrations on one hand, and the expected conclusions or deductions on the other hand, was somehow abstract to the student. The teachers may be unaware of the fact that deductions from findings, which are obvious to them, may not be so to the students. The students appear not to see the logical link, and thus reach wrong conclusions. It is not that the students are unable to learn some concept or principle. In fact, the identification of such "too far" inferences and the splitting of a long logical step into shorter illustrative ones, will enable the student to participate again in the process of learning;
- Once the students switch from using mechanically the mathematical formulas to an understanding of the operations they perform, they tend to prefer lengthy computations, each step of which they understand over shortcut and convenient formulas, the meaning of which is not directly perceivable. Just as they require a concrete image of biological entities, they dislike abstract, if convenient, formulas;
- The fact that the mathematical computations cannot be the basis for the learning, doesn't mean that we should give up on dealing mathematically with the quantitative aspects. On the contrary, they appear to play an essential part in the learning of biological phenomena, for they confer them reality and concreteness. As far as the students are concerned, there is a type of interaction between biology and mathematics: biology imparts a meaning to the mathematical tools, and in turn, mathematical tools confer reality upon biological entities and processes;
- As shown by students' testimony, mathematical anxiety may be greatly reduced by using the learning sequence recommended here, i.e., starting without mathematics and using mathematical tools only when the students know exactly what they have to compute ,and why;
- In "concrete" situations, that is to say, when they deal with familiar objects with defined dimensions, most of the students can reach a state where they use correctly the quantitative principles they have being learning. However, a not–negligible portion of the students are unable to become less dependent on concrete situations and to apply mathematical concepts and principles to symbolic situations (problems in which objects and/or dimensions are represented by symbols). This does not mean that biological principles with intrinsic quantitative aspects cannot be taught at the junior high–school level.

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Table 1: The development of a meaningful conception of the surface to volume ratio in organisms of different sizes, and of its influence on inward or outward motion of food or heat. (Questions are shown in italics).

Students responses to questions	**Description of stage of understanding**
["Who will suffer more from cold?"]	
"The mouse, because he is smaller so he will loose more heat."	The student answered intuitively, on the basis of their experience
"The mouse, because he is small and that's why he will absorb cold faster."	
"The mouse, because he is small and material penetrates fast to things that are small."	
["Who will suffer more?"]	
"We can't know because it's relative. The elephant has huge surface area and volume, and the mouse	Here we see the misconception: the size doesn't matter, because a big

has small surface area and volume." " If we talk about volume, the small is more efficient and if we talk about surface area the big is more efficient. If we talk about both it is relative 1:1, it reduces itself and there is no difference between them." " The elephant, It doesn't sound reasonable but it is bigger, so its' ratio is bigger."	body has more surface and more volume *and* the surface/volume in ratio is constant (1:1) when size changes, or is bigger in big bodies.
"What does it mean that the ratio of surface area to volume is 3?"] " The surface area is grater 3 times than the volume." " It can be 3:9, 1:3, – Both give ratio of 3."	Students refer to a purely technical, meaningless mathematical operation.
While working with the "Hungarian" cube: *[" If we look at the small cube, from how many sides can it absorb material or heat?]* student: 6 [And the cube at the corner?] student: 3 [And the cube next to it?] student: 2 Student: and there are some cubes that haven't any absorption sides."	This exercise brings the students to understand , to actually see, the reason for the different ratios. They use meaningfully the term "ratio". No need yet for formal mathematical computations.
Later during discussion: *["The ratio is 6:1, what does it mean?]* Student: 1 unit of volume absorbs from 6 sides "	Students able to express their understanding of the concept of surface area to volume ratio
Finally, comparing the big and small cubes Student:" the cube at the corner has 3 sides to absorb but there are cubes that have just 2 sides or hasn't any sides at all. There are 27 cubes and 54 sides to absorb." ... Student: " the ratio of the big cube is smaller, it is 2:1 while the small cube has ratio of 6:1." Student:" the *same* volume in the small organism absorbs from more sides, so the surface area to volume ratio is bigger compared to the big organism."	The students express correctly the ratio of surface area to volume of the big cube and compute it by means of a division. The mathematical operation is now meaningful to the student

A Characterisation of Practical Proposals to Teach the Philosophy of Science to Prospective Science Teachers

Agustín Adúriz-Bravo, *2083065@ticeu.uab.es*
Mercè Izquierdo and Anna Estany,
Universitat Autònoma de Barcelona, Spain

INTRODUCTION

The philosophy of science has been recognised by recent scholarship as a key contribution to the transformation of science education for the twenty-first century, in accordance with the new and ambitious aims that have been proclaimed for democratic scientific literacy in many countries (Duschl, 1990; Driver et al., 1996; McComas and Olson, 1998; Millar and Osborne, 1998). The philosophy of science may be of great help in achieving the goals that have been put forward for the preparation of future citizens, due to its critical nature and its power to inform public understanding of techno-scientific issues involving complex political, economic, environmental and ethical components (McComas et al., 1998; Monk and Osborne, 1997). This is an important consideration in the current panorama, in which science pervades every aspect of everyday life but, at the same time, faces strong attacks from antiscientific scholarship, such as the so-called sociology of scientific knowledge (Matthews, 1998).

With this general background, the need for the introduction of the metasciences (the philosophy, history and sociology of science) in the school science curriculum and in science teacher education has been repeatedly advocated in the literature of didactics of science during the last fifteen years (Duschl, 1990; Matthews, 1994, 1998; McComas, 1998). Metascientific contents are recognised as a fundamental component of the contemporary ideal of scientific literacy (Millar, 1989; Monk and Osborne, 1997); this component has been labelled the *nature of science* (McComas, 1998) or ideas-about-science (Millar and Osborne, 1998). Thus, there is consensus that it is necessary for the educated citizen of the twenty-first century not only to know science but also to know *about* science: how it is created, how it evolves through history, and how it relates to society and culture. As the report *Beyond 2000* puts it,

> young people need an understanding of how scientific inquiry is conducted – to help them appreciate the reasoning which underpins scientific knowledge claims, so that they are better able to appreciate both the strengths and the limitations of such claims, in a range of situations and contexts. (Millar and Osborne, 1998: 11–12)

Apart from this intrinsic value, contents from the philosophy of science have long been considered as a powerful auxiliary tool for the teaching and learning of science. That is, *instrumental* aims have also been advocated for the philosophy of science in science education. According to this, several topics from the philosophy of science have been introduced in the science curriculum and in science teacher education. On the other hand, the philosophy of science is considered a strategic field within science teachers' professional knowledge (Bromme and Tillema, 1995), influencing other fields, such as their ideas on teaching and learning science. Hence the interest of didactics of science to conduct research on teachers' ideas on the nature of science and to issue proposals to improve them (Lederman, 1992; McComas, 1998). The philosophy of science may be of great help for science teachers who face the challenge of preparing future citizens.

Taken this into account, we have focused on the examination of available proposals regarding the integration of the philosophy of science in science teacher education. We have dealt with this integration by means of a theoretical framework that has allowed us to assess the available proposals (Adúriz–Bravo, in press–b). In this paper, we are going to present one particular dimension of this framework, the *structuring theoretical strands*, and we are going to use it in the analysis of three didactical units that have been designed to teach philosophical contents to science teachers.

PRIOR KNOWLEDGE

Science education and didactics of science, that is, the practice in schools and the scholarly discipline reflecting on this practice, have had a development until recently that was scarcely related to the philosophy of science; this situation has been portrayed as a 'mutually exclusive development' of the two fields (Duschl, 1985). Rationales and practical proposals in science education are even nowadays mainly informed by educational and psychological research, largely disregarding ideas coming from the disciplines that study the nature of science. In the last fifteen years, however, this tendency is increasingly being reverted; there has been integration of the fields of science education and the philosophy of science through the work of scholars such as Duschl, Hodson, Lederman, Matthews and McComas (Matthews, 1998).

The study of the different relationships between the philosophy of science and science education constitutes today an expanding area that comprises several very active research lines, such as conceptual change (Nersessian, 1992), nature of science (McComas, 1998), use of historical case–studies (Duschl, 1990), debate around constructivism (Matthews, 1994; Osborne, 1996), and epistemological analyses of didactics of science (Adúriz–Bravo, 1999). These research lines involve the use of different models drawn from the philosophy of science; the adaptations made to these models have proved sometimes to be insufficient or defective (Adúriz–Bravo, 1999), lagging thirty years behind current philosophical debates. As research and development informed by this simplistic or outdated philosophy of science permeate into science educational practice, it can be expected that some science curricula, instructional materials, and science teacher education courses show an incomplete or inadequate view of the nature of science.

In addition to this, there is an enormous amount of evidence showing that prospective and in–service science teachers often lack an adequate view of the nature of science (Koulaidis and Ogborn, 1989; McComas et al., 1998). Teachers' naive epistemological images are generally found to be similar to those developed by the philosophical school of *logical positivism* during the first half of the twentieth century. It has been suggested that these insufficient or incorrect ideas affect teachers' classroom behaviour and influence their students' images of science (Lederman, 1992).

These are powerful reasons supporting the need to closely inspect the teaching and learning of the philosophy of science within the context of didactics of science; we confer high priority to the study and discussion of this issue, taking into account that *the nature of science forms the core of future citizens' scientific literacy*. We are carrying on an attempt of critical inspection of the issue by analysing some of the available proposals to teach the philosophy of science that have been advanced within didactics of science. We have collected over sixty of these proposals to form the data base of our study; to assess them, we have developed a new theoretical framework (Adúriz–Bravo, in press–b). In the following section we outline this framework; the fourth section is devoted to inspect with some detail the particular dimension that we have selected for this paper. We then present three proposals to teach topics from the philosophy of science to science teachers; the proposals are analysed in some depth in order to show explicitly how our construct can be used.

CONTEXT OF OUR INNOVATION

We are concerned with pre– and in–service education of science teachers for the different educational levels from kindergarten to university both in Spain and Argentina. As one of the reviewers of this paper has pinpointed, teacher education courses start from the basis of presupposing in students some knowledge on the nature of science, which should have been acquired during their scientific education. Such assumption is often simplistic and is challenged in our theoretical framework.

This framework aims at assessing proposals that address the teaching of the philosophy of science as an important aspect of science teacher education. Such assessment is done according to several analytical dimensions: dimensions giving factual information on the proposals; dimensions that respond to curricular questions, helping to put the proposal into context; and dimensions regarding the contents of the proposals. Initially, a set of six dimensions provides information that may be of use when retrieving them from their original sources; seven further dimensions characterise the proposals according to their curricular traits:

1. *Populations*. This answers the question: Who are you teaching the philosophy of

science to? There are several populations of students that didactics of science may consider of interest; we have grouped them according to their specific needs in relation to the philosophy of science that they should learn. We talk about three populations: *science students, science teachers, and didacticians of science*.

2. *Contexts*. This answers the question: When and where are you teaching it? McComas and others' (1998) distinguish four contexts in which the philosophy of science can be taught to teachers. We use three, extending them to our populations; these contexts are: *science courses, metascience courses*, and *didactics of science courses*.

3. *Goals*. This addresses the question: What do you expect from this teaching? Some authors analysing the teaching of the philosophy of science as one dimension of science education have recorded different goals (Matthews, 1994; Driver et al., 1996); we suggest that three main groups of goals can be identified: *instrumental goals, specific goals, and cultural goals*.

4. *Method*. The question is: How are you implementing it? This dimension examines the nature of the activities that are used to teach the philosophy of science. Methods include lectures, workshops, lab work, investigations, small group work, dramatisations.

5. *Relationship with a discipline*. The proposals may be related to a specific discipline (physics, chemistry, biology), either because of their contents and examples or because of the population they address.

6. *Content–anchoring*. Some topics of the philosophy of science (such as the hypothetico–deductive method) are a result of a reflection on any or all disciplines, independent of their contents. Other topics are posed by the development of a particular scientific field; for instance, the ontology of quantum mechanics.

7. *Stages*. These are the periods of the philosophy of science that the proposals select to teach, and use as a source. We have developed a scheme that reviews the history of the philosophy of science in the twentieth century, and provides a dynamic picture of the development of this discipline. Our scheme considers three stages that in part overlap:

7.1. *Logical positivism and received view*, roughly covering from 1920 to 1970. The constitution of the Vienna Circle is considered the starting point for our identification of contents. This first analytical approach to the philosophy of science is mainly syntactic, and draws heavily from formal logic.

7.2. *Critical rationalism and the new philosophy of science*, going from 1935 to 1990. Several different schools within this stage may be united because of their profound critique to logical positivism and their introduction of external (i.e. historical and social) considerations.

7.3. *Postmodernism and contemporary accounts*, starting with Paul Feyerabend's radical statements about science in the early 1970s and going on to the naturalised philosophy of science of the late 1990s. This last stage represents a return to classical questions, revisited with new conceptual tools.

In addition to these seven dimensions, we identify the main concepts from the philosophy of science that are addressed in each proposal; for this task, we use a specific theoretical construct, the strands (Adúriz–Bravo, in press–b).

THEORETICAL STRANDS

Our theoretical framework draws on models for science curriculum design that have successfully used the so–called *structuring ideas* (Sanmartí and Izquierdo, 1997). A structuring idea traverses a scientific discipline and permits to organise different specific models around it; in this sense, structuring ideas work as keystones of the science curriculum architectonics. We have imported this design idea to apply it to the teaching of the philosophy of science. In order to analyse the contents from the philosophy of science in the proposals that we have collected, we have developed six sets of structuring ideas; we have called them *strands*. These strands organise the philosophical concepts, models, sources and activities that can be identified within the proposals. We will very briefly elaborate on the strands; more detailed information can be found in another paper (Ad_riz–Bravo, in press–b):

1. *Correspondence and rationality*. This first strand comprises two main aspects of scientific knowledge: the way in which it is believed that theoretical entities and reality fit, and the rational criteria that scientists use to assess this fitting. These two questions have been in the foundations of the philosophy of science since its earliest stages.

Regarding the first matter, several different units of epistemological analysis have been proposed (concepts, models, theories), and two main opposite philosophical views –*realism and instrumentalism*– have been advocated to map these units onto the real world. These two broad views of correspondence have used specific constructs to explain the relationships between theoretical and observational terms (Hempel, 1966). As to the second aspect, traditional philosophers were concerned with the logical structure of scientific judgement; this approach is called *hard* rationality. It was only with the new philosophy of science in the 1960s that external (social and historical) factors were incorporated into the analysis of theoretical choices (Kuhn, 1970).

2. *Representation and languages*. This strand concerns the different structural units that philosophers of science have produced in order to account for the process of representation of the natural world. Traditional analyses are theory–based, assuming that theories are at the top of the scientific hierarchy, and that formal disciplines achieve maturity when axiomatically organised. The current *model based view*, derived from a semantic conception of scientific knowledge, challenges this excessively formalist approach (Giere, 1988).

Theories and models as abstract entities are characterised by linguistic propositions that make them communicable, especially through textbooks. This fact has generated the need for a study of scientific language both from traditional discourse analysis and from the new perspective of *rhetoric* (Newton et al., 1999).

3. *Intervention and method.* This strand includes the classical neo–positivistic account of a unique, well–defined scientific method that precedes research and comprises a fixed series of steps, starting from observation and ascending to scientific laws. Several variations to this scheme have been proposed since the 1930s, including Popper's (1963) very elaborate *falsificationism*. Among recent contributions to the discussion, we highlight methodological models that focus on the construction of paradigmatic experimental facts through writing (Izquierdo, 1994); these models partly stem from the new sociology of science and are of great interest for didactics of science.

4. *Contexts and values.* This strand regards the relationship between science and the general social, cultural and educational contexts, which are characterised by their own aims and values. Traditional accounts have disregarded such relationships advocating a strong *neutrality* for science. Science was portrayed as a value–independent activity aimed at the discovery of truths about the world that are of value by themselves, independent of their use, sources, power and consequences. More recent views on the social nature of science frontally challenge these assumptions; philosophers add to the classical contexts of discovery and justification those of innovation and education, proposing an axiological study of the scientific endeavour (Estany, 1993).

5. *Evolution and judgement.* This strand involves a diachronic study of the theoretical entities that constitute the core of science. The traditional philosophy of science sketched a rather static picture of the scientific enterprise, producing a cumulative view that disregarded the study of the mechanisms of *conceptual change*. New models, following Kuhn's (1970) account of scientific revolutions, focus on the nature of knowledge shifts. Another aspect of interest to analyse scientific evolution is the study of the ways in which scientists make reasonable choices between competing explanations. In this issue, the contributions of the cognitive philosophy of science (Giere, 1988) are of the utmost relevance, as they propose a *naturalised* approach to the concept of rationality.

6. *Normativity and recursion.* This last strand focuses on the recursive, metadiscursive nature of the philosophy of science, that is, on the fact that the discipline is a second order discourse theorising about science that can turn onto itself to perform a self–analysis of its own validity and reach (Estany, 1993). This so–called *metaphilosophical* analysis permits to distinguish between a strongly normative approach to the discipline, in which general a priori parameters are sought, and an explanatory approach, considering the philosophy of science as another empirical discipline.

ANALYSIS OF PROPOSALS

During our work with teachers, we have collected and adapted several existing proposals to teach different philosophical topics; these proposals are addressed to various populations within the context of science education and are available in the existing literature (for instance, in McComas, 1998). Many of these proposals are directed to the improvement of the teaching of various scientific contents (Abd-el-Khalick and Lederman, 1999), but we are here concentrating only on the aim of teaching the philosophy of science per se, independent of such derivations. We will now analyse three proposals that have been issued for the purpose of teacher education in specific topics of the philosophy of science, showing explicitly how they address the theoretical strands exposed above.

Scientific reasoning and detective novels

This first didactical unit (Ad_riz-Bravo, in press-a) is aimed at the teaching of a set of central concepts from twentieth-century philosophy of science, such as *explanation*, *reasoning* and *inference*, that are considered important within science education (Duschl, 1990; Newton et al., 1999). This is done by using a world-famous detective novel, Agatha Christie's *Death on the Nile*, in book and film format. We oppose Christie's construction of the narrative (by means of deductive reasoning) to Hercule Poirot's solution of the criminal enigma, which draws heavily on *abductive* patterns. Classical logic, modelling, and the role of reasoning and creativity in scientific discovery are examined through paper-and-pencil tasks and small group discussion.

Models of *correspondence* from stages 1 and 3 are constantly opposed using an analogy that compares detective investigation and scientific inquiry; the syntactic approach, typically developed by logical positivism, is compared to the semantic approach, characteristic of contemporary schools such as the cognitive philosophy of science. The opposition between these models is achieved through the analysis of three kinds of inferences: deduction, induction and abduction. Traditional philosophy of science has concentrated on the opposition between inductive and deductive reasoning, combining both in the *Aristotelian method* (Hempel, 1966), which is in the base of many well-known introductions to the nature of science in textbooks and courses. Abduction as a logical mechanism for scientific explanation has been largely disregarded in the philosophy of science and in science education, but it is currently recognised as a core element in the process of scientific modelling (Giere, 1988; Thagard, 1992) that should be taught at school. This proposal recovers abductive reasoning as a powerful formal analogy of the process of modelling.

With the emergence of a semantic conception of theories within the philosophy of science in the last thirty years, a *model based* view was developed (Giere, 1988), and subsequently moved to the areas of cognitive science and didactics of science (Duschl, 1990). This philosophical approach is interested in how theories are produced and selected, how they make sense to scientists, and how they are used and learnt, rather than in their mere formal structure of deductively concatenated axioms. Within this conception, models are the key entities of theoretical thinking; scientific modelling can be regarded as a process of abduction from theory-laden evidence to abstract theoretical organisations (Giere, 1988; Thagard, 1992).

This proposal has adapted original sources from philosophy of science (among others: Samaja, 1994), a procedure that is yet uncommon in science education but that has been heavily recommended (McComas, 1998). These sources are introduced together with their application to the narrative, in order to effectively anchor the analogical process. We will present here a sketch of the proposal with its main features. The activity begins by exploring the structure of classical detective novels in terms of its key elements: crime, suspects, clues, investigation. A first approach to the formal structures of Hercule Poirot's solution to the mystery and Agatha Christie's construction of the plot is asked from teachers. Later on, formal argumentation patterns for the three main kinds of inferences are presented; here we use Samaja's (1994) Spanish version of Charles Sanders Peirce's (1967) canonical presentation, as follows:

* Three statements are considered: *p*. All the beans from this bag are white; *q*. These beans are white; and *r*. These beans are from this bag.

* These statements are combined in the following three inferential patterns: *I*. If *p* and *r*, then *q*; *II*. If *q* and *r*, then *p*; *III*. If *p* and *q*, then *r*. Pattern *I* is called deduction, pattern *II* is called induction, and pattern *III* is called abduction. Abduction can also be structured in the form of a categorical syllogism, in which the if–clause is called by Paul Thagard (1992) a *rule*.

Instances for the three ways of reasoning are extracted from the book, and with this framework, the author's and the character's procedures are opposed: abduction is presented as a "reverse" deductive mechanism, or an ascending inference starting from incomplete evidence. The instructional unit ends with the transposition of these content–free apparatus to specific examples from science; among these, we have used the relationship between evidence and models in the fields of atomic structure and interior of the Earth.

The pendulum as an international standard of length

This second didactical unit has been elaborated by Michael Matthews (2000). It uses some episodes selected from the history of modern science to illustrate the rich contextual relationships between science, technology and society. This example initially concentrates on Christiaan Huygens' late seventeenth century proposal to adopt the *seconds pendulum* as an international standard of length, relating this issue to strategic problems such as measuring longitude at sea, achieving accurate time–keeping, or simplifying commercial weights and measures.

One of the aspects that this proposal deals with in detail is the question of why the French revolutionaries chose the expensive and time–consuming geodetic determination of the metre when Huygens' chronometric determination had been readily available for over a century. This question allows the author to deeply combine topics from the strands of intervention and method, and contexts and values; he critically examines some key matters about the topic of *theory testing*, and about the interrelation games between science, politics and economy.

Dialogue between two pharmacists

This third didactical unit (Izquierdo, 2000) concentrates on the strands of contexts and values, and evolution and judgement. Within the classical genre of a dialogue between two (not so) imaginary scientists, widely used in philosophy and didactics of science, an extensive and elaborate text opposes two historical views on pharmacy, the *botanical* and *iatrochemical* conceptions. The scene, set in Paris in the early seventeenth century, highlights the underlying general (philosophical, religious, aesthetic) values of these two views; such values to a great extent determine the scientists' theoretical and methodological commitments, obstructing "objective" exchange between them.

The problem of theoretical change is also examined through opposing two research traditions and their supporting powers, interests and institutions. The goals of this proposal are achieved by means of a dense historical setting that provides the readers (in-service teachers) with tools to enact and further develop the proposed situation.

CONCLUDING REMARKS

This paper is based on the acknowledgement that the philosophy of science is a fundamental component of future citizens' scientific literacy, and consequently must be infused into science teacher education. Current programmes show several shortcomings in their philosophical basis; the theoretical tool that we have presented intends to help in the improvement of such programmes.

Our theoretical framework is enhanced when combined with other models to identify key issues in the philosophy of science and to evaluate proposals to teach them (for instance, Loving, 1998; Abd-el-Khalick and Lederman, 1999). We have found that the set of strands may work as a very powerful didactical tool, as it provides science teachers with an extensive overview of the philosophy of science that makes it more meaningful, and allows them to seize the relevance and usefulness of philosophical contents for their professional development and for the preparation of future citizens. In science teacher education, strands also help us do a *pragmatic* selection of contents from the philosophy of science that is informed by didactics of science, and combines elements from competing research lines.

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The Development and Implementation of a "Science and Technology for All" Program in Israel

Rachel Mamlok and Avi Hofstein, The Weizmann Institute of Science, Israel, *rachel.mamlok@weizmann.ac.il*

Ruth Ben–Zvi, Naomi Ernst, and Dvora Cohen, The Weizmann Institute of Science, Israel

INTRODUCTION

The timely publication of the National Science Education Standards (NRC, 1996) was an important step in identifying a set of goals for achieving scientific literacy for all American students. Briefly, the National Science Education Standards (NRC, 1996) define in broad terms the scientific concepts and processes that all students should be familiar with and be able to apply.

This paper describes the development and implementation of a new "Science and Technology for All" program in Israel (Tomorrow 98, 1992). This program consists of a set of about 20 modules (40–45 learning hours each), all with an STS type structure and content. Each module focuses on a specific scientific topic. Several examples of modules that have been developed and implemented, are as follows: *Energy and the Human Being* (Ben–Zvi, 1998); *Brain, Medicines and Drugs* (Cohen, 1998); *Forensic Science* (Ernst, 2000). When teaching the modules, teachers are expected to use a wide range of pedagogical and instructional techniques, in particular, to encourage inquiry and student participation, to cope with students' different aptitudes and to motivate them, and to enhance the classroom learning environment.

BACKGROUND

In the '80s and '90s "Science and Technology for All" emerged as a slogan that embodied a new challenge for science educators during the stages of its development as well as the implementation of the curricular process (Bowyer, 1990). Harms and Yager (1981) state that science and technology should be part of the education of those who will eventually be what they call "future citizens."

In recent years, the worldwide use of these goal clusters served to develop science teaching in its authentic context (Yager, 1996). For example, Science/Technology/Society (STS), which regards science within its technological and social milieu, promotes the use of the four clusters to shape the character of science–literate citizens. Such a population will be able to understand not just the contents of science but also its relationship to society and to global issues (Penick, 1984).

STS programs are by definition interdisciplinary in their approach (Bybee and Trowbridge, 1996). This approach provides the teacher with a wide range of techniques, diversifying classroom instruction and improving the classroom learning environment. Consequently, the students' motivation to learn science increases (Hofstein and Walberg, 1995).

The implementation of a wide spectrum of instructional techniques in the science classroom implies the prerequisite of matching an assessment tool to each technique to measure the student's achievements and progress (Gitomar and Duschl, 1998).

SEVERAL EXAAMPLES OF MODULES THAT HAVE BEEN DEVELOPED AND IMPLEMENTED

Energy and the Human Being (Ben–Zvi, 1998)

The module "Energy and the Human Being" was developed with the idea of exploiting this intuitive notion of 'free energy' (Ross 1988) . The following section describes how this is done by pointing at the difference which exists between energy that is transferred as work ("free" to perform work), and energy that is transferred as "heat" and wasted.

Two main issues constitute the backbone of the program:

a. Work is performed when a spontaneous process is coupled to a non–spontaneous process, thus causing it to happen.

b. Energy can be converted from one form to another but each transformation is accompanied by some of it being transferred as heat and thus the ability to perform work decreases.

These two main themes, i. e., a. that the difference in a system's energy can either be transferred completely as heat, and thus wasted, or some of it can be harnessed by being transferred as work, and b., that this harnessing is done by coupling a non–spontaneous processes with spontaneous processes, are broadened to include systems from different knowledge areas: physics, chemistry and biology.

Relevant aspects of the module

The teaching sequence starts with presenting some ideas of the importance of energy in the lives of all of us, for example, in transportation, household and kitchen appliances, and food and dieting, which for this age group is a very interesting and important issue. In this context students are reminded of the law of conservation of energy which they have learned in the senior high school. this law is used in the framework of eating and dieting:

$$\begin{array}{c}\text{amount of energy}\\ \text{absorbed}\end{array} = \begin{array}{c}\text{amount of energy}\\ \text{used}\end{array} + \begin{array}{c}\text{amount of energy}\\ \text{stored}\end{array}$$

The discussion continues with the links that exist between the welfare of a society and the energy it has at its disposal. Comparisons are made between various societies at different stages of human history and between different countries at present. Discussions with students center on many of the basic problems of existence such as the availability of energy sources, the need to conserve energy sources and the price society has to pay for each energy source used.

Brain, Medicines, and Drugs (Cohen, 1998)

"Brain, Medicines and Drugs" focuses on several selected aspects of brain research and its relationship to human behavior and feelings. The Module presents scientific questions and the development of scientific ideas as well as updated knowledge of scientific content in brain research and human behavior and feelings. Following that, the effects of drugs on brain, hence on human behavior and feelings are presented.

Learning this module acquaints the students with multidisciplinary, updated relevant scientific content in the area of brain research and effects of drugs on the brain. "Brain, Medicines, and Drugs" encompasses issues as scientific ideas, and the close interaction among science–technology –society (STS). Updated scientific contents of brain research, human behavior and feelings. The effects of drugs on them are presented through a variety of teaching strategies to promote and enhance learning. Variety of learning environments are thus incorporated in the process in the classroom: debates, discussions, movies, groups, peer instruction, games, and case studies. The module enables flexibility in contents and instruction methods according to the special interaction that occurs in class in the meeting among teacher–student–curriculum in aim to create meaningful and enjoyable learning experience.

The implementation was characterized by teachers' training prior to teaching, support and discussions of knowledge as well as sharing experiences and events from classroom. These, and students assessment were an important feedback resource for another spin of the spiral of the development spiral.

Learning this module has a potential to contribute to the effort to avoid drug abuse, and tools for personal and social decision making in the present and future.

Forensic Science (Ernst, 2000)

One of the goals of scientific literacy is to enable students to read newspapers critically. Acquaintance with scientific investigations of the police allows them to read critically reports concerning forensic science in newspapers. Another goal of scientific literacy for all is advocating value judgment and decision making (Bybee & Ben–Zvi, 1988). The advances in forensic science in the last years, such as DNA "fingerprints" for example, have raised social issues (DNA database for the entire population and the human genome project in this case) that need resolving.

The recommendation of the "Tomorrow '98 Report"(1992) for science curricula for non–science majors is to use interdisciplinary and multi–disciplinary approaches. Forensic science is an interdisciplinary field, using technological applications of natural sciences as well as exact sciences. The module is thus interdisciplinary too, introducing subjects from biology, chemistry, physics and statistics.

Scientific Subjects in the Module

The module Forensic Science will include four chapters, each dealing with another aspect of police investigation.

- *Finger prints, or why are burglars using gloves*

This chapter introduces subjects such as the skin: its importance and structure, the sweat: its content and function in balancing body temperature, chemical reactions–ways for developing unseen finger prints, evaporation and inter molecular forces and statistics–mainly probability.

- *Whose blood is this?*

In this chapter students will learn about the composition of blood, enzymes catalyzing biochemical reactions, antigens and antibodies, the immune system, blood groups

(ABO and Rh) and blood typing.

- *The nucleus of truth*

This chapter introduces DNA–its structure (macro and micro), role in heredity, techniques for multiplying DNA in the lab, restriction enzymes, electrophoresis, more advanced probability and genetic engineering.

- *True or false?*

Learning about the polygraph enables students to become acquainted with electrical conductivity, the heart– its structure and function, heart beat rhythm and blood pressure – physiological and mental influences, respiratory organs– structure and function, calculating average and presenting data graphically.

The students carry out experiments such as developing their own finger prints, chromatography, using gel electrophoresis for DNA analysis, microscopic observations, measuring their heart beats and blood pressure before and after physical effort, etc.

It is suggested in the teacher's manual to arrange for the students visits in a forensic laboratory, watch forensic technicians at work in the local police station, etc. The police are inclined to collaborate with such activities as they usually feel a need to improve its image in society. Showing the scientific quality of investigations to future citizens is a good way for the police to do so. For the students these are valuable experiences, increasing motivation for studying. Debates and/or court role–plays on current social issues such as acceptance of polygraph test results in court, DNA database for entire populations, advantages and disadvantages of genetic engineering will be held after studying the relevant subjects.

FIELD TESTING AND EVALUATION

Developed during 1996 – 2000, three of the modules *(Energy and the Human Being; Brain, Medicines and Drugs; Forensic Science)* were field tested during one school year and then revised. Implementation and dissemination after revision was accompanied by intensive and comprehensive teacher professional development activities and evaluation of students and teachers.

Energy and the Human Being tries to clarify some issues concerning abundant feelings about energy. *Brain, Medicines and Drugs* focuses on several selected aspects of brain research and its relationship to human behavior and feelings. *Forensic science* introduces subjects from biology, chemistry and statistics, and deals with the use of technological applications of latest scientific advances.

The teachers who were involved with teaching the modules had initial training in biology, chemistry or physics, and typically taught students who majored in the sciences. These teachers were not initially trained to teach curricula that included interdisciplinary issues (Blumenfeld, Fishman, Krajcik, Marx & Soloway, 2000). Teachers attended training activities related to the history and nature of science as well as pedagogical techniques.

Before and during their teaching of the modules, the teachers attended 50 hours of professional development – lectures, discussions, and workshop dealing with the relevant topics. They often worked in small groups and discussed the interdisciplinary nature of the content, the difficulties in coping with such topics, and the required teaching methods.

To assess the outcomes, we incorporated qualitative methods, which involved close observation of lessons, interviewing students and teachers, and describing and analyzing events. The experimental group consisted of 10th grade students not majoring in science, who studied the module.

FINDINGS

After studying the modules most of the non–science oriented students changed their negative attitudes toward science and science studies. In fact, some of them began to show some interest in the phenomena around them. This was manifested in their reading science sections in the daily newspapers and watching science programs on television. They brought to class interesting clippings from the papers and shared them with their classmates, and they spoke about science programs in lessons devoted to the subject. In interviews they remarked that “We don't turn off the television anymore when we happen to see a program devoted to a scientific subject.”

Most of thee students claimed that in their former studies they were discontent with the science studies because they were afraid they would be unable to cope with formulas or with mathematical computation. Therefore, studying without formulas or mathematical computation changed their attitude to science studies and lessened their rejection of science. The students claimed that this method, which gave them a better understanding and an overall view of the subject, stimulated them to like it and enhanced their interest.

Many also remarked that the variety of teaching methods utilized contributed a great deal to the learning and comprehension of the material. They liked the experiments which in turn simulated them to perform experiments, make films, and to prepare and present articles and projects before their classmates and teachers.

SOME CONCLUSIONS

We hoped that using an interdisciplinary approach to teach science to high school students would affect positively their attitude toward science, in general and scientific studies, in particular. Based on our contact with teachers using these modules, we have now recommended that:

* Science concepts be taught effectively within a relevant context and based on anchoring events (Cognition and Technology Group at Vanderblit, 1992).

* Prior to and during the implementation of a new curriculum, teachers should be involved in preparation workshops including the development of auxiliary learning materials, and they should receive continuous support from the curriculum developers (Blumenfeld, Fishman, Krajcik, Marx & Soloway, 2000).

Although our conclusions were not fully supported by our data, we also feel that the pedagogy used with a new curriculum should examine a variety of instructional methods that have proven to be effective in learning science and in developing positive attitudes toward science and toward learning science (Hofstein & Walberg, 1995).

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Science for Everyone: A Problem–Based Learning Approach

George Watson, *ghw@udel.edu,*
Barbara Duch, *bduch@udel.edu,*
University of Delaware, Newark, USA

The University of Delaware has established a reputation for successfully implementing problem–based learning (PBL) in undergraduate courses in all the science disciplines, particularly at the introductory level. A core of science faculty initiated the PBL reform at UD that subsequently spread across our entire undergraduate curriculum. We present aspects of two of our courses as a context for the discussion of PBL and science education: SCEN102 Physical Science and SCEN103 Silicon, Circuits, and the Digital Revolution.

PBL is an instructional method that challenges students to "learn to learn", working cooperatively in groups to seek solutions to real world problems. These problems are used to engage students' curiosity and initiate learning the subject matter. PBL prepares students to think critically and analytically, and to find and use appropriate learning resources. In fact, PBL is actually one of the most familiar, and oldest forms of learning, learning that is initiated by a question, curiosity, or puzzle. It is the way that small children naturally learn before formal education, and it is the way successful professionals learn once they have finished their formal education.

At its most fundamental level, PBL is characterized by the use of "real world" problems as a context for students to learn critical thinking and problem solving skills, and acquire knowledge of the essential concepts of the course. Using PBL, students acquire life long learning skills that include the ability to find and use appropriate learning resources. The process used in PBL is the following:

1. Students are presented with a problem (case, research paper, videotape, for example). In their groups, they organize their ideas and discuss previous knowledge related to the problem, and attempt to define the broad nature of the problem.
2. Throughout discussion, students pose questions, called "learning issues", on aspects of the problem that they do not understand. The group records these learning issues. Students are continually encouraged to define what they know – and more importantly – what they do not know. Unlike traditional instruction, students are taught the importance of acknowledging areas of ignorance, in order to focus their research time.
3. Students rank, in order of importance, the learning issues generated in the session.

They decide which broad questions and issues will be researched by the whole group, and which ones are more narrow, and can be assigned to individuals.

4. Students along with their instructor discuss which resources and other materials will be needed to research the learning issues, and most importantly, where they may be found. After a period of time, in which students pursue researching their learning issues, they reconvene to discuss the learning issues and integrate their new knowledge into the context of the problem. Students are also encouraged to summarize their knowledge and connect new concepts to old ones.
5. They continue to define new learning issues as they progress through the problem. Students soon see that learning is an ongoing process, and that there will always be (even for the teacher) learning issues to be explored.

What is the faculty role in PBL? The instructor must guide, probe and support students' initiatives, rather than lecturing or providing easy solutions. The degree to which a PBL course is student–directed versus teacher–directed is a decision that the faculty member must make based on the size of the class, the intellectual maturity level of the students, and the instructional goals of the course. When faculty members incorporate PBL into their courses, they empower their students to take a responsible role in their own learning, helping them to develop into independent lifelong learners.

PBL is appealing for several excellent reasons. Carefully constructed, open–ended problems help develop critical thinking skills. Through such problems, students encounter concepts in contextually rich situations that impart meaning to those ideas and enhance their retention. In encouraging students to assess their own knowledge, to recognize deficiencies, and to remedy those shortcomings through their own investigations, PBL provides them with an explicit model for lifelong learning. Through PBL, students learn how to learn, how to ask the right questions to arrive at solutions.

In addition, the group format teaches students the power of working cooperatively, fostering not only valuable communication and interpersonal skills, but also a sense of community in which diversity becomes a strength, enhancing the learning experience for all. PBL addresses the real concerns of industry and graduate schools – that fresh college graduates come prepared with problem–solving skills and be able to communicate effectively across disciplines and work with others to solve a problem. Finally, the inquiry–driven nature of PBL makes it ideally suited for a research university environment, with the multiple resources for investigation and independent learning such a setting enjoys.

Problems are used to introduce various ideas or topics and to serve as focal points for learning new material. Students may find this a bit unusual if they are more accustomed to working on problems after the pertinent material has already been thoroughly presented in lecture. Our purpose in using PBL is to have the problem provide a context and reason for learning the material. Students are not expected to be able to come up with a solution instantly — good PBL problems are meant to encourage a dialogue within student groups about what knowledge or insights each student brings to the situation, what information collectively they still lack, and where to find that information. Students in an introductory science course typically have a wide range of backgrounds and experiences in science, but each can make a valuable contribution to the efforts of the group. Some students may have more "content" knowledge than others, and will be able to test just how deep that knowledge is, by trying to explain an idea to someone else. Others, by virtue of being unfamiliar with a particular area, can often help their group see a situation from different perspectives and, through their questions, make certain that all in the group finish with a true understanding the material.

The end-of-chapter problems typically found in traditional science texts encourage students to memorize and pattern match rather than think, estimate, and problem-solve. Problems should require students to go beyond rote solutions and promote more engagement with the material. Unfortunately, problems and materials appropriate for use in PBL courses are not readily available in current science texts, requiring many instructors to develop their own. For faculty seeking to adopt problem-based methods, lack of materials is a real barrier to change. Science faculty members who have attended PBL workshops at the University of Delaware have expressed the need to have access to well written PBL problems to implement problem-based instruction in their own courses.

We are developing instructional models and materials, which are accessible to faculty worldwide through an online clearinghouse. The database of problems, instructional models, evaluation tools, and Web-based resources will incorporate PBL effectively across the content framework of introductory physics. Materials are being collected and reviewed for a wide variety of introductory physics courses. Selected clearinghouse problems will also be adapted to the high school setting. The structure of the clearinghouse, sample problems, and the submission/editing process will be presented. The web location of the PBL Clearinghouse is <http://www.udel.edu/pblc/>.

SCEN102: PHYSICAL SCIENCE

< http://www.udel.edu/physics/bduch/>

SCEN102 is an interdisciplinary science course that focuses intensely on four key concepts:

Motion and mechanical forces

Materials and their properties

Electricity and circuits

Solar system

These topics have been selected because they are central to an understanding of the scientific topics that affect our daily lives and understanding of the world around us. In spite of what students may have been taught in some earlier context, we know of course that science is not an accumulation of dry, disconnected trivial facts. It is organized common sense, an evolving and changing way of understanding the world around us, of making sense of what we see, hear, and learn from experiments.

This course is designed to fulfill the science component of the general education requirements. The objectives of the course, then, are related to the objectives of the general education requirements themselves. Successful students in this course will learn what science is, how scientists understand the universe and its contents, how science improves our understanding of everyday events, such as traffic accidents and water pollution, and how this understanding changes our lives.

Why is it important that an educated person learn about science? An educated person, in order to function as an employee, citizen, and worthwhile human being in today's world, needs to be familiar with a number of areas of human knowledge as well as to have some skills. Virtually every University in America recognizes this fact and has some set of general education or "core" requirements.

What we hope students will do, after taking this course, is to have an interest in science throughout their lives. We hope they will occasionally look at some of the science specials that appear on television from time to time. We hope that they will read one of the general interest science magazines (Scientific American, Science News, and Discover). We hope that as a parent or prospective schoolteacher, they will enjoy communicating the excitement and beauty of science to children.

"Narrower Yet Deeper; Less Is More". In the past ten years many reports have stated that the American educational system is in crisis. One widely proposed solution in science education is to "cover" fewer concepts but go into depth on the ones you do cover. We seek an understanding of some of the deeper concepts that underlie our understanding of nature, our comprehension of the Universe, and of some of the major physical concepts that affect our lives. That is why we will focus our learning around the four major topics listed above.

COURSE OBJECTIVES

The PBL format of this course provides the opportunity to develop the basic skills and understanding of content in the areas further described below. Mechanisms for assessment of student performance such as exams and evaluations provide the opportunity for students to demonstrate the progress they have made in meeting both the content and skills objectives listed below.

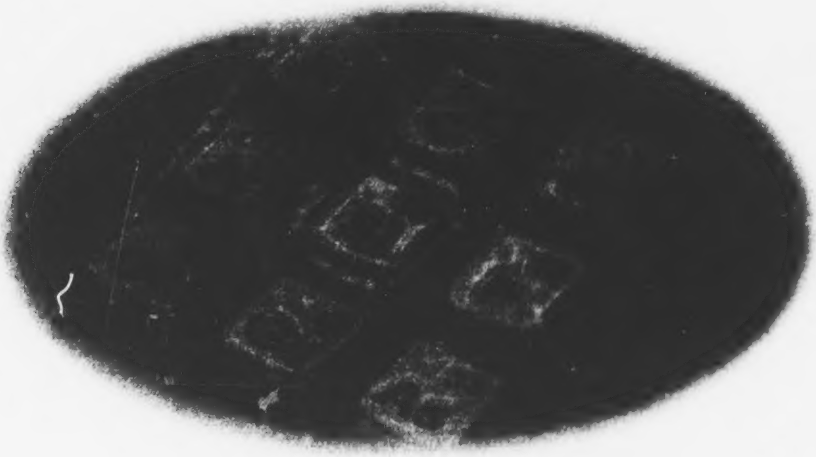
1. Sketch graphs to represent the motion of an object, and describe motion as represented by a graph.
2. Calculate the speed and acceleration of an object using data (gathered experimentally or derived from graphs).
3. Design and conduct a series of investigations to determine how changing an object's mass and forces acting on an object affect its motion.
4. Use knowledge of forces that cause motion to solve realistic automobile accident.
5. Understand relation between speed and stopping distance.
6. Construct series, parallel, and combination circuits and predict which circuits will be best for a variety of needs.

7. Understand and be able to explain the transfer of energy in many different phenomena, including automobile accidents, swinging pendulums, electrical circuits, and sunlight.
8. Explain how electricity is used to light appliances in a house or apartment.
9. Understand and be able to explain that matter is composed of different kinds of atoms, and use this understanding to help you solve some real–world problems.
10. Understand and be able to explain the physical and chemical properties of matter.
11. Distinguish between physical and chemical changes of matter.
12. Use data gathered using a variety of separation techniques to identify the components of a sample of material.
13. Understand why common astronomical phenomena(such as lunar phases and the seasons of the year) occur.
14. Demonstrate the connections between a model of the solar system and the changing appearance of the moon in the night sky.
15. Use data about the planets to write a research proposal to NASA.

In addition, various activities in the class are designed to introduce students to ways of taking this understanding several steps further – i.e., towards applying the concepts they have learned to new situations, synthesizing concepts to build a new (higher level of) understanding, and using their knowledge and understanding of physical science to build reasoned arguments for a particular point of view. In addition to learning concepts and principles in physical science, the PBL format also allows students to gain practice in the following areas of competency, which should be "generalizable" to other areas of study and experiences.

1. Communicate the results of an investigation or research project orally, graphically and in writing.
2. Reason critically and creatively.
3. Make reasoned decisions in unfamiliar situations.
4. Pose questions that aid in self–directed learning, and the learning of others.
5. Identify, find, and analyze information that's needed for a particular task.
6. Communicate ideas and concepts to others.
7. Collaborate productively in teams.
8. Gain self–confidence necessary to use thinking and communication skills in a public setting.

This course has previously been offered to up to 240 students per section in a large auditorium; currently it is being taught in sections of 120 students the main class gathering, breaking out into discussion and laboratory sections of 24 students assisted by teaching assistants. It is a challenge to develop a "learning" community environment in a large class. In using problem–based instruction with permanent groups in the large class and associated lab and discussion sections, we are attempting to do just that. We also focus on current and interesting problems that will motivate students and help them build a framework of understanding of the important concepts in the course.



SCEN103: SILICON, CIRCUITS, AND THE DIGITAL REVOLUTION

<http://www.physics.udel.edu/watson/scen103/>

Technology — a means to an end, not an end in itself...
How does a compact disk work?
How does my computer work and what can I do with it?
What is the Internet and what use is it to me?
What is the interplay of science and technology?

SCEN103 was most recently offered as an Honors colloquium, introducing first-year students to some of the science behind high technology. Designed to promote scientific and computer literacy and awareness, this course gives students an opportunity to expand their interests in everyday devices and high-tech objects into a study of fundamental science concepts. Live demonstrations, in-class group explorations of technology applications, and daily work with the Internet are essential elements of this course. A key feature of the writing-intensive work for this colloquium is the students' setup and development of a personal website. Working in small groups, students also create websites devoted to a science and technology topic.

This course relies heavily on problem-based learning (PBL). Students work collaboratively in groups to solve real world problems. By using PBL in SCEN103, they learn to apply simple scientific concepts, find and evaluate scientific and technical information, and communicate ideas about science and technology to others. Discussions led by the course instructor, plus supplementary lectures, help to give a context and conceptual framework to the problems.

The rate of generation of new information in the scientific and technical sectors is truly staggering. Information becomes outdated rapidly and is updated constantly; much of what students will need to know in the workplace following graduation has not yet been generated! Thus identifying when new information is needed, where to find it, how to analyze it, and how to communicate it effectively are essential skills for students to learn as undergraduates. An important result of using PBL is that while problems are used to identify what to learn, the process of learning "how to learn" is also developed. This method of instruction has been chosen for SCEN103 to help students develop skills important for success both in their undergraduate education and in their professional life following graduation.

Course objectives

1. As a result of successfully completing this course students should be better able to:
2. Analyze simple electrical circuits to assess their function and effectiveness.
3. State and describe fundamental scientific principles underlying modern electronic devices.
4. Explain the basic operation of electrical circuits, simple semiconductor devices, and integrated circuits.
5. Identify the contributions of science and technology to everyday life.
6. Interpret graphical data and construct graphs to communicate ideas.
7. Communicate technical ideas orally and in writing.
8. Evaluate the information content of Internet resources.
9. Use graphical and other multimedia elements effectively in a web page.
10. Create an informative and organized website devoted to presenting a topic of technical interest from various perspectives.
11. Access timely, relevant, and authoritative information for problem solving.
12. Construct technical information into a logical framework for decision making.
13. Establish a frame of mind where quantitative reasoning is embraced.
14. Work effectively in a group to solve complex problems.

SUMMARY

Teaching introductory science to typical undergraduate students is a challenge that few will deny. Problem–based learning is a student–center approach that engages students in solving real–world problems while "learning how to learn". Designing PBL courses for this student body demands that instructors reflect on what is relevant and create problems that will help students develop a solid understanding of scientific concepts. Participating in this process turns us into reflective practitioners, where we learn along with our students and continuously improve learning in our classrooms.

Ethical Implications of the New Genetics: A Preliminary Study of a Pedagogical Challenge

Ralph Levinson, Institute of Education, University of London,
r.levinson@ioe.ac.uk

INTRODUCTION

The new science programme in the English national curriculum enjoins science teachers to address the ethical issues in science (DfEE/QCA 1999). It takes as unproblematic the challenges that teachers may face in exploring contemporary controversies in science. Biomedical research, for example, is developing with great rapidity and the social and ethical problems concomitant with these changes are, to some extent, unpredictable. So, how well–equipped are school science teachers to deal with topical ethical and moral questions associated with the new biomedical technologies? And what might be appropriate criteria to judge effective teaching about ethics in a science context?

Of the many controversial issues in science, advances in the genetic and reproductive technologies have a personal relevance for students. These technologies, and the underpinning science, are also important in teaching citizenship in a science context. Understanding the implications of a genetic screening programme, for example, and the possibility of having an inherited genetic condition, concerns not only the individual but also his or her family and the wider society. Decision–making is likely to involve the private morality of the concerned individuals, their specific socio–economic contexts, their personal and social relationships and their educational background. Contemporary debates about cloning human tissue and genetically modified food indicate that political decisions about approval are sensitive to public opinion. For example, the Human Genetics Commission, a non–executive advisory body to the UK government has circulated a questionnaire to the public on their attitudes towards developments in genetics.[1] The dissemination of information resulting from genetic testing has important civil rights implications. Formulating public policy and creating the conditions for democratic accountability on these issues presuppose a citizenry that has some grasp of the underlying science and an awareness of the values base. Young people entering medical vocations, the social services and teaching will need an appropriate background that enables them to deal with the many ethical, social and legal questions that will arise. The school education of an emerging lay and professional citizenry is crucial in providing a forum for rehearsal of these issues (Nuffield Council of Bioethics 1993).

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[1] HGC Business: Consultations. See http://www.hgc.gov.uk

A recent project, carried out by a team at the Institute of Education, University of London, for the Wellcome Trust, looked at the teaching of social and ethical aspects of developments in biomedical science (Levinson and Turner 2001). Questionnaires were sent to teachers and headteachers in 1000 schools in England and Wales followed by 111 interviews with individual teachers and groups of teachers across the curriculum. Conclusions from the research report indicate that critical thinking, participation in debate and discussion of controversial topics are far less a feature of science lessons than they are of lessons in the humanities. Science teachers tend to have an epistemological view of science as value–free. There are few instances of using expertise across the curriculum to address these issues and very few teachers, whatever their subject specialism, explicitly teach ethical principles.

While there is an emergent literature of students' attitudes towards these technologies (Hill et al 2000, Levitt and Whitelegg 1998) and students' argumentation patterns in discussing ethical issues (Ratcliffe 1997) there has been no empirical research on the teaching of these issues (Reiss 2000). Yet it is the teacher who will need sensitivity and expertise in mediating debate and possible conflict, introducing new knowledge, which is changing at an astonishing pace and will be expected to bring together different forms of enquiry – ethical and scientific. Teachers will need to be sensitive to aspects of controversy while possibly having their own conflicting thoughts and feelings; many will have had personal experiences that have a bearing on the topic being taught.

Scientific enquiry is different from ethical enquiry. Scientific enquiry is perceived to be about procedures that produce knowledge through the description and interpretation of nature whereas ethical enquiry, in the context of science, raises questions as to how we ought to act in relation to this knowledge. Procedures and concepts are distinct in these two domains although new knowledge in science may feed into the ways in which ethical questions evolve. Thus, the technology of pre–implantation diagnosis effectively offers parents the opportunity to select potential babies on their genetic characteristics. The question may arise as to whether it is acceptable to screen out potential babies who are shown to be carriers rather than sufferers of conditions such as cystic fibrosis – a question it would have been meaningless to ask before this technology became available. It may even be possible to ask if parents could select children for relatively trivial purposes, such as height and eye colour. Should individuals be allowed to make this choice? What is the boundary between acceptable and unacceptable selection? With potential treatments for many genetic conditions, should any selection be acceptable? What are the ethical grounds for decision–making on these issues?

Science specialists in England and Wales are no more trained to teach ethics than they are, say, history, geography or music. The approaches and methods for teaching science may be very different from those needed to pursue ethical questions. The ways in which science teachers approach ethical questions may depend on their perceptions of the nature of science: is the practice of science perceived as value–laden and susceptible to ethical enquiry? Or is science perceived as neutral and beyond the limits of ethical questioning? Students may perceive science teachers as experts on the new genetic and reproductive technologies when the latter are only too aware of the limitations of their own knowledge. Physics and Chemistry specialists may find teaching this topic as difficult as if they were non–scientists. Finally, teachers may not have had the opportunity to rehearse their own attitudes when thinking about ethical dilemmas in biomedicine and may have had significant personal experiences, which may influence their attitudes.

An exploratory pilot study arising out of the Wellcome study has focused on developing empirical tools to study the teaching of ethical issues in controversial areas of science, with the purpose of formulating generalisable hypotheses that can be evaluated on a larger scale. While ethical ideas and perspectives can be taught in a transmissive way, any understanding of them relies on belief, experience and emotions. Indeed the immediacy of research in the new genetics is the implications for individuals, families and communities. Any educational context that presupposes skills of citizenship and the roles of citizens in a democracy is based on students rehearsing arguments and debate. Interchange of ideas in the classroom in science, and certainly ethical issues in science, should involve opportunities for talk, discussion and argument. (Newton et al 1999). This preliminary research study focuses on the role of the teacher in shaping these opportunities and in locating those tools that help to characterise the forms of discourse initiated by the teacher. The research therefore draws on ideas of discourse analysis, more specifically, the work of Edwards and Mercer (Edwards and Mercer 1987), and their debt in turn to Bruner and Vygotsky, in locating the framework within which young people at school or college are socialised into a culture of knowing.

THE CONTEXT

The medium that was chosen for the study is a one year post–16 course, *Science for Public Understanding(SPU)*. As the name of the examination course suggests, one of the important aims is to cover a range of issues which members of the public will need to understand if they are to participate in scientific and technological decision–making. (Millar 2000). It thus stands distinct from other syllabuses that have a more overt science content, and the course attracts non–science as well as science students. The module selected is based on developments and ethical dilemmas in the new genetics covering inherited diseases, antenatal screening and pre–implantation genetic diagnosis. Four two–hour sessions were observed by the researcher, a fifth session not attended by the researcher, brought together strands of the module and a previous module for examination purposes. In the first session the teacher addressed the underlying science concepts – genes, chromosomes, alleles, dominance, recessive, genetic conditions, fertilisation, (including *in vitro fertilisation*), zygote. The second session broadened out the range of genetic conditions and the need for screening. Discussion of ethical dilemmas – the focus of this study – occupied the third session and the fourth session addressed the topic of designer babies through the video *The Gift*.[2] A wide range of strategies were used: videos, direct teaching, group discussions, true and false statements, question and answer sessions.

There are twenty four students on the course, although two did not attend any part of the module, and numbers attending the sessions varied from 22 to 12. For three of the four sessions, however, twenty or more students attended. There are ten young men in the group and fourteen young women, and in each session there were always slightly more women than men.

The teaching sessions take place in a further education (FE) college in London. A further education college is distinct from a secondary school in that it is usually larger and runs many more courses, including a mix of vocational and academic courses. Mature adults attend courses at FE colleges and often work in classes with students in the 16–19 age group. Most of the students in this group are in the 16–19 age group, although there is a Somali refugee in her early twenties who, the teacher told me, had a disabled two–year old child. The class is ethnically diverse, consisting of refugees from Afghanistan and Somalia, students from the Asian sub–continent, Afro–Caribbean students as well as white students. The class reflects the ethnic diversity of the college, and those of many schools and colleges in metropolitan areas of the UK.

THE RESEARCH STUDY

The course tutor is an experienced teacher, a chemistry specialist, who has taught SPU since the course was being developed in 1997. Researcher and teacher agreed dates for the researcher to observe the teaching of the module. In an initial interview the teacher discussed the components of the course and the educational background of the students. Most students had some qualification in science and about half were doing academic or vocational post–16 courses in science. Letters were sent to all the students on the course outlining the aims of the research project and asking for their co–operation, offering them the opportunity not to take part. No students opted out. Due to the nature of the timetabling in the college it was not possible to interview the students.

The course tutor gave students a small task, consisting of three short questions based on a popular newspaper article about designer babies, before and after the teaching of the course. The task revealed predominant student conceptions: test–tube babies are fertilised in a test–tube; test–tube babies develop and, sometimes, are born outside of the womb; pre–implantation genetic diagnosis is 'unnatural'; and designer babies are 'engineered'. Responses were coded by the researcher and blind–coded by the teacher with insignificant differences but the sample was too small to check for indicators of learning.

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[2] Information about this video and the company that produced it can be found at: http://www.ytouring.org.uk/

The teaching room is small, unattractive and noisy and the researcher sat in a corner, able to observe students, without being obtrusive. Audio–tapes of the teacher's talk during the lesson were taken and transcribed. Two groups of students were also recorded during group discussions and their conversations and dialogue with the teacher were also transcribed. Classroom talk was logged on a 30 second timeline and regular timed observations taken of teacher strategies, position in the classroom, gestures, activities of two randomly selected students, resources, lesson content and researcher's thoughts. Copies were taken of all paper resources used. An initial coding of lesson transcripts and interviews were carried out after the first two sessions and used for categorisation in the third and fourth sessions.

Semi–structured interviews took place with the teacher at the end of each session. These covered:

- the teacher's description of the session and perceptions of what was learned;
- responses to 'significant moments' in the lesson raised by both researcher and teacher;
- impressions of what students had learned;
- the teacher's understanding of what students knew, understood and felt before and during the session;
- challenges perceived by the teacher;
- responsibilities of the teacher in discussing particular ethical dilemmas.

RESEARCH CONTEXT

There has been much advocacy of a move towards a consideration of social and ethical issues in the science curriculum (Millar and Osborne 2000, Millar 1996, Solomon 1993, Aikenhead 1986, AAAS 1993), but such teaching programmes have to operate within the predominant discourse of classroom talk. The teacher is conceived as scaffolding the student's learning (Vygotsky 1978) so that knowledge is handed over from teacher to student (Bruner 1983). Learning, however, takes place in the context of the classroom and is mediated by both the teacher's and students' implicit understanding of the ground rules of educational discourse (Edwards and Mercer 1987). Beyond the ostensible confines of talk are the beliefs and shared understandings that both teacher and students bring to the classroom. Edwards and Mercer have produced a list of discursive devices that typify classroom discourse and the aim of this preliminary interpretive study is to capture and to problematise the nature of the interactions between teacher and student. In session 3 the teacher concentrated on teaching aspects of ethical dilemmas which contextualised the science previously taught. The analysis is divided into a. The teacher's comments at the beginning of the module; b. A discussion of three classroom interactions in session 3; and c. The teacher's comments in an interview at the end of session 3. Any names mentioned have been changed.

ANALYSIS AND FINDINGS

Pre–module interview

The teacher outlined her hopes and challenges for the topic. It should be 'interesting' and 'enjoyable' and within the SPU course it is the subject 'that gives most scope for debate, where there are really no right answers.' Her objectives were that the students would have the 'confidence to weigh up these issues', to 'improve their discussion skills' and to be 'aware of other opinions so they can freely make up their own minds.'

To achieve these objectives the teacher's strategy was to ensure the students were 'fairly clear' about the science because in issues where there is a 'fuzzy morality you have to grasp quite a bit more science to actually understand what's happening'. Given time constraints in covering the content of the module, the teacher acknowledged there was a potential tension between teaching the substantive science concepts and the time needed for open and reflective discussion of the moral and ethical issues that emerge from ethical dilemmas.

Other problems she felt she would face were that it 'would be easy to go off on a tangent and to be easily sidetracked.' The students were thought to be 'not very good at discussions'.

Teacher–student interchanges

Session 3 turned out to be the most interactive session. It was characterised by long tracts of teacher talk interspersed with interventions from students, and from one student in particular. During the first hour of the session the teacher asked one closed question but there were a series of questions, clarifications and counter–arguments from students.

Table 1. Time from beginning of session: 630s

Context	*Exchange*	*Code*	*Researcher thoughts*	*Teacher reflections from interview*
The teacher has discussed a couple where the mother is considering having an amniocentesis to test for Down's Syndrome and is mapping a scheme on the whiteboard to identify the consequences of taking different decisions. Directly before this interchange the student asks how an amniocentesis is carried out and how the test can precipitate a miscarriage.	S: So why doesn't it happen all the time then? T: Because you don't poke around inside the womb all the time. S: What I mean is it's one in one hundred (chance of miscarriage). Everytime they do that test, it's one in a hundred . . T: Yes. That's right. Well it probably depends . .some pregnancies are more . . some people seem to hold their pregnancies better than others, may be it depends on the skill of the surgeon who's doing the procedure. I honestly don't know. Most biological things are like that, aren't they, there's a random finite chance of one thing happening or the other, it's not absolute. Most biological things are like that. S: Yes, but not with the same severity. T: You know if there's flu going around in this room will half of us catch it and the other half won't? S: Yes but if we catch it we're not going to die, are we? T: No. But that's not the issue, we might do . . S: Of course it is. Obviously it's more important if someone's going to die than someone's going to catch a cold, do you know what I mean? T: Yes it is. But the question of why is not one we can answer, it's biological randomness, things are all different, and the reason we're all different is partly genetic, of course. Right. So if she does have the test . . .	Spontaneous contribution from student.	A sense of growing irritation between teacher and student. His contribution interrupts her purpose of listing the possible consequences on the board.	' there's an element of showoffness' 'you do need to move the lesson forward a bit.' 'It is difficult if someone takes a fundamental Islamic position as he does. I felt it was a discussion the others wouldn't have responded to at that point.

The student queries the consequentialist position presented by the teacher. Having an amniocentesis involves risk of a miscarriage but teacher and student interpret the concept of risk in different ways. To the student any risk is unacceptable if it endangers the life of the foetus; in the teacher's presentation the risk of miscarriage is but one factor to take into account when making a decision. Understanding the concept of risk is not a problem for the student, it is the moral framework within which he treats the nature of risk that creates the difference between his argument and the teacher's. The student's ethics are predicated on a religious basis (in this case stemming from his Islamic beliefs) so he makes a very clear distinction between 'natural' miscarriages as being due to the will of God and miscarriages resulting from human intervention as wrong. In a later group discussion on the consequences of testing for Down's Syndrome the student outlines his position at the beginning of the activity: 'From my Islamic beliefs . . . we're told that God gives us tests in different ways, yeah? If we see any little problem that we're running away from then we're not standing up to that test, even if we don't understand things now.' Differences between teacher and student in this interchange reach an impasse with the teacher affirming 'that's not the issue' and the student countering 'Of course it is'. The teacher shortly continues her narrative with a rhetorical flourish 'Right'.

Edwards and Mercer have characterised the basic I–R–F structure in classroom teaching as a commonality of all patterns of classroom discourse; there is an Initiation by the teacher, a Response by the student and Feedback by the teacher. The IRF framework can be extended, as this section of classroom exchange illustrates, to student assertion with a follow up by the teacher (Martins et al 2001). Misunderstanding generated through the student's intervention appears to be more than a breakdown in shared understanding of the implicit rules of classroom discourse. Negotiating beliefs in ethical perspectives constitutes a more formidable challenge to the teacher, as these are balanced against the content knowledge to be taught and the inclusion of all the class in the discussion. The intervention is problematically dismissed as 'showoffness' and the difficulties in discussing a fundamentalist position.

Table 2. Time from beginning of session: 840s

Context	*Exchange*	*Code*	*Researcher thoughts*
Having laid out the different options for testing or not testing for Down's Syndrome the teacher contrasts the consequentialist position compared with making decisions from absolute basic principles.	T: I think the group actually discussed this case in the first place had a completely new approach to this. They looked at absolute basic principles. They didn't look at the consequences of which is going to lead to maximum benefit or for utilitarian reasons the maximum happiness. Um S: Happiness for who? T: Well for me, it will balance out different people. It's the same balancing act that we're talking about, balancing the consequences, right? And you're right, it's a good point, you've raised a good point, it's not just a case of looking at it for you, but you've also got to consider other people in the equation as well in the particular case we're looking at, the Down's case. I think we can probably argue that the issue is really that of the two parents, but I think you're right Asif to remind me there that another factor you might well consider is the other two children.	Spontaneous intervention from student followed by teacher response	Teacher acknowledges intervention but I feel misses the point about who's happiness. Isn't student referring to the unborn baby?

This highlights a similar problem between the same student and the teacher but this time the teacher commends the validity of the student's intervention. Within twenty seconds she explicitly approves his point three times and builds it into her continuing narrative. But the irony in this exchange is that the teacher absorbs the student's comments into her utilitarian argument whereas his point comes from an absolutist worldview. The 'happiness' he is referring to is the potential happiness of the foetus who might die whereas the teacher is alluding to the happiness of all those parties other than the foetus. There is a clear misunderstanding.

Table 3. Time from beginning of session: 3720s

Context	*Exchange*	*Code*	*Researcher thoughts*	*Teacher reflections from interview*
The students are about to see a video on screening for thalassaemia in Sardinia. The teacher then opens up the question as to what would happen if someone knew they carried a gene for thalassaemia.	T: If you know you're a carrier, then what can you do about it? S1: Don't marry another carrier. T: Well that's the first one. Don't marry another carrier. Several students: How do you know?/ Don't you need to test them? T: Yes. Test them before they get married, and if they're both carriers . . . Several students: That's a bit extreme/Harsh/test them? S2 (Asif): How can you say it's harsh? You don't think having an abortion's a bit harsh? I mean you think stopping them getting married is a bit hard, but you don't think when you're killing a baby that that's a bit harsh, that's a woman's right and all the rest of it. (general disquiet, voices raised in disagreement) S3 (female): Do you choose your partner, do you go out with.. or would you marry….'Oh by the way, are you a carrier?' S2: Yeah. I would say that. S3: Oh, you would do? (hubbub of voices) S2: Looking at it in context, you're making a big deal about stopping people getting married, but you're not making a big deal about having an abortion, which is even worse. T: Well ok fair point. Can I just say that there are in many societies where marriages are arranged for all sorts of reasons. But there is no evidence that arranged marriages are any less successful than marriages based on the free choice of partners.	Teacher elicits response from students followed by spontaneous contributions.	Students feel strongly about this. Testing a partner is fraught with problems for them and they don't seem to know how to handle it. Teacher concludes talking about arranged marriages in relation to Greek Orthodox Church in London and thalassaemia present in Cypriot population. Don't think this has been presented to students yet . . non sequitur.	'As a chemistry teacher who's used to much more control because there's less to discuss. . . if you're trying to explain the bonding of benzene there's a fairly finite answer . .or even the ethics of CFCs.' ' . . problem of letting go so they can enjoy their free discussion but making sure you're managing the learning situation as a whole . . ' 'I'm not used to managing this interplay as much as, say, an English teacher (teacher of English)'.

This example is different in nature to the other two because it begins with the teacher eliciting a response from students. Identifying whether a future partner is a carrier of thalassaemia or not provokes an unruly discussion. The teacher does not take part in the interchange which revolves around the problem of directly broaching the question with a potential partner. This touches the emotions and sensitivities of young people and has raised a point of concern but the teacher quickly diverts the interchange with the potential solution of arranged marriages. Managing the issues of sensitivity and the rights of the unborn child pose serious management problems to the teacher.

Post–session interview

Many of the teacher's reflections on this session are incorporated in Tables 1 to 3. She has clearly identified problems in achieving her teaching objectives, and these problems reside mainly in controlling discussion. On prompting from the researcher to clarify problems in controlling discussion, the teacher elaborated the tension between the students enjoying their 'free discussion' and 'making sure you're managing the learning situation as a whole'. Free discussion is perceived as 'illicit' talk, attempting to remove the teacher's attention from the subject discourse. (Levinson et al 2000)

DISCUSSION

Several themes have emerged from analysis of the lesson transcripts involving classroom exchange and teacher interviews, 'control of discussion', 'teacher–student difference in belief systems', 'distinct classroom discourse between science and ethics'. The focus of this paper is not to generalise from an exploratory study but to identify those categories and questions that would characterise the qualities science teachers bring to, and the challenges they face in, areas of controversy in science, and the encouragement of participative debate and critical thinking (Rudduck 1986). The challenges identified by the teacher in 'control of discussion' are consistent with those found in the Wellcome Trust study.

> 'I remember that there was something about genetics that came up, looking at animal testing. At the end of the video a couple of kids picked up on it and there was a debate and I wasn't really involved. One child spoke vehemently against testing for cosmetics. And these sort of issues are raised in an uncontrolled way and that's part of the problem and can catch people unawares.' (Science Teacher, School A) (Levinson and Turner 2001)

It is a different proposition to manage I–R–F patterns of classroom talk of substantive science concepts compared with the ethical issues raised by students. Scott, for example, has reviewed studies of classroom discourse in science (Scott 1998), but these studies rarely transcend science concepts and procedures. As we have seen, broaching ethical issues can have an effect on the teacher's authority, which changes the power relationships and subsequently the nature of the classroom discourse. Edwards and Mercer's categories are drawn from studies with younger children. There needs to be a broader description of the cognitive and affective domains that a teacher has to contend with in a discussion of ethical issues in a science context. These domains have been shown to include:

- substantive science concepts: e.g. 'gene', 'carrier', 'chromosome';
- nature of science: e.g. 'reductionist', 'susceptible to values', 'uncertain/certain knowledge'
- technological concepts, (know–how): e.g. procedures of an amniocentesis
- procedural concepts: e.g. 'probability', 'risk', 'screening';
- ethical concepts: 'religious beliefs' (teleological); 'acting according to strict moral principles' (deontological); 'appraising and balancing consequences' (consequentialist/utilitarian);
- feelings and emotions, sensibilities: how you and a partner might feel about being a carrier; 'killing a baby', relationships within the family;
- contextual factors: students' and teachers' beliefs and attitudes shaped by their own personal experiences.

Categorisation and analysis of classroom discourse helps to identify the interplay of teacher assumptions located in the teaching context. But there is a need for a probe that can distinguish how teachers treat different aspects of knowledge and the way teachers approach the interaction of these aspects of knowledge in the classroom. Development of a model for analysis might include the sources of teachers' knowledge, the forms of knowledge defined by Shulman (Shulman 1986) and elaborated to include teacher's knowledge of self (Turner–Bissett 1999).

It is demanding a lot from science teachers to address the ethical aspects of contemporary science issues: few teachers, whatever their specialism, can handle this area with much confidence or experience. This is not due to any inadequacy on the part of the teachers but to the complexity of the issues. These new technologies are loaded with imponderables: assessing risk, the complex nature of the scientific process (how much can teachers know whether experiments have been carried out with proper controls in place; the different assessments of the developing technology); changes in both the nature of the ethical and legal processes as the technology develops. These are difficult tasks for government appointed committees staffed by experts, let alone teachers who have pastoral, administrative and academic duties, and a varied curriculum over which they cannot possibly have full up–to–date knowledge all the time. As we have seen the teacher has to work across domains and deal with different forms of enquiry. Translating the objectives of science for public understanding – citizens' science – to the micro–processes of teaching in the classroom is deeply problematic.

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Difficulties in Transforming the Knowledge of Science into School Knowledge

Krystallia Halkia, University of Athens,
kxalkia@primedu.uoa.gr, halkia@otenet.gr

INTRODUCTION

During the last decades, more and more people have become increasingly dependent on complex technology. Therefore, it might be expected that there would be a continuously increasing interest in subjects being at the core of science and technology. Instead, the literacy in science is remarkably low (Physics on stage, Project description, 2000).

In Greece, research addressed to the student population revealed that Secondary school students characterize physics as one of the most difficult and least favorable subjects found in secondary school programs of study (Halkia and Karanicas 1999).

We believe that this situation is largely due to the difficulties now facing the transformation of the knowledge of science into school knowledge. The designers of science curricula, and consequently the science textbook writers, often do not take these difficulties into consideration in primary and secondary education. This is primarily the reason why, although a lot of class hours are spent in teaching science, it is usually with poor results in student performance and interest.

The core of these difficulties depends upon three interconnected parameters: the scientists–researchers, the teachers and the students (Kariotoglou 2001). These three parameters have quite different conceptions about the nature of science, as well as a quite different interest in science; sometimes they converge and at other times they diverge from one another.

The scientists–researchers are the "producers" of scientific knowledge, they possess the scientific methodology and they can keep track of the technological products and the scientific principles on which these products are based. The teachers– educators are the "negotiators transformers" of scientific knowledge into school knowledge. They decide which concepts of science should be taught in classrooms today and they possess the educational methodology to teach these concepts properly. The students are targeted as the "consumers receivers" of this scientific knowledge. They have their own interests in special scientific regions; they also have their own way of perceiving the physical world, which is very different from that of the scientists. They cannot easily keep track of the scientific principles and the final technological products and the scientific laws and principles on which these products are based.

Thus, there is a gap between the knowledge of science as it has been constructed over the last five centuries and is continuously produced today in Laboratories, Institutions and Universities and the subject of science as it is taught in science classrooms.

FACTORS HINDERING THE TRANSFORMATION OF SCIENTIFIC KNOWLEDGE INTO SCHOOL KNOWLEDGE

Science is a complex subject to be made accessible to primary and secondary school students. It presupposes the mastery of certain skills and a special way of thinking. Yet it is crucial for the understanding of our world and human civilization. Thus, the way scientific knowledge is transformed into school knowledge demands serious thought, careful design and skillful treatment.

In achieving that transformation, some of the crucial factors to be taken into consideration are:

- *The limits of the human senses as the first and prime medium used to study the world:* Through these senses, the student perceives the world, observes it carefully and constructs – mainly subconsciously – his/her first and most powerful theory of the world's functions (Harlen 1986). But, while human senses are the prime medium used to study the world, science extrapolates this study beyond the capabilities of those senses. Thus, a very small part of the information coming from the entire world surrounding us is actually perceived by the human senses. The major part of the crucial information is perceived through the aid of special instruments and apparatus, which are considered to be the extension of man's physical senses. The scientific theories are based and verified on the entire information spectrum perceived from the world around us and presuppose that the receivers can create specific representations of these theories. The understanding of the microcosm or the macrocosm demands: a) the extension of the world's representations based on common experience, and b) as a result of that, the creation of abstractive models of the world's functions.
- *The complexity of science tools (experimental methodology and mathematics) necessary to understand the physical world and the laws conditioning that world:* These tools are intrinsic parts of students' science understanding. The proper use of these tools presupposes the mastering of mental and practical skills, which is the result of many years of effort. The students' acquaintance with these tools should gradually follow their age potentialities. Thus, students could understand the importance of these tools in formulating final scientific conclusions. Unfortunately, in science classrooms, an effective way of making students properly conversant with these tools has not yet been reached, although from time to time some innovative suggestions have been attempted. In many instances, the application of these suggestions has failed because of teachers' weakness in making use of these suggestions (Nuffield Science Projects 1966).

- *The students' mental capabilities:* Frequently, the mastering of the complex tools of science (e.g. integral calculus), as well as the ability to follow the syllogisms leading to the inspiration of science theories (e.g. Quantum Mechanics), overcome students capabilities. Most students of school age have not yet reached the level of abstract reasoning necessary to understand the mathematical formalism and the rhetoric of science (Piaget 1953). Science curriculums and science textbooks often target higher levels of thinking than those of the addressed student' population (Adey 1994). This creates feelings of inadequacy in students studying science and is one of the crucial factors in causing negative attitudes towards science.
- *The students' preexisting ideas about the world:* Students come to school having already shaped specific conceptions (mainly alternative conceptions) about the way the world functions (Driver 1983). These conceptions usually diverge from those of the accepted scientific model and present very strong resistance to any change, since they have been shaped through personal experience.
- *The everyday language used in education to explain the formalistic language of science:* The language of science is mainly formalistic and is dominated by mathematics. It consists of the communication code between science researchers and science teachers and corresponds to a "mental language". On the other hand, to teach science in primary and secondary education demands the frequent use of everyday language as a means of communication between science teachers and their students, which is a "sentimental language" (Guiraud 1989). In science classrooms, the teachers use the everyday language as a mediator between the code of science and the communication code of students (Sutton 1992). The description of science concepts and the explanation of physical laws in everyday language cause some problems. Often it can strengthen students' alternative conceptions, since everyday language is expressed and is affected by the everyday experiences in the natural world. In addition, everyday language is affected by social experiences too (Solomon 1987). Thus, it carries an ideological "load" which is culturally determined. As a result, it introduces an additional "noise" in teaching the concepts of science (Guiraud 1989).
- *The positivistic view of science:* Science has been established for five centuries. During these centuries, especially in 20th century, it has been succeeded an enormous accumulation of knowledge in several areas. Because of that fact, there is pressure to transmit a significant part of that knowledge in primary and secondary education. The efforts to teach as much science as possible in science classrooms have forced the curriculum designers to present the "knowledge" in a condensed form. This has led to the domination of an undisputed positivism, which has been diffused throughout science textbooks and science teaching. Thus students get the notion that science is not a continuously developing body of knowledge, but a finished one; the reverse of the modern conception of what science really is. On the other hand, students are unprepared to manage the postmodern view of the rela-

tivism in science and are led to confusion. Thus, in science classrooms, the appropriate stimulus must be offered to students so that they realize that science is a continuously developing body of knowledge and is ready to be modified if such an indication results from research (Koulaidis and Ogborn 1994). Only then would they assimilate the fact that science is realistic, it follows processes which obey rational syllogisms and produce reliable knowledge (Longbottom and Butler1999).

- *The notions of science researchers (producers of science knowledge) about school science and their intensions to intervene in education:* Recently, there has been a growing interest by the researchers in several fields of science, working in Institutes and Universities, in educational matters. They often make suggestions about the kind of science content that should be taught in primary and secondary education. Usually they push for more and more content be included in the school science curricula and since they are people with high prestige, their opinion counts. They are experts in science, but they have not studied the didactics of science. So, their suggestions are lacking in didactical effectiveness and their decisions block the attempts of the designers of science curricula.
- *The plethora of information ("knowledge") contained in science curricula:* There is a tendency, especially by the science researchers of the university community, to press the educators to include in science school–curricula most of the recent scientific findings. Thus, it is now being attempted to transfer to secondary education, regions of scientific knowledge, which a decade ago were taught in universities. The argument for this descent of science knowledge, from universities to secondary education, is that in such a way students would be taught more modern and interesting subjects. But an argument like that ignores the fact that the main goal is to teach and not just to inform. Most of this kind of suggested science knowledge demands a highly abstract way of thinking and strenuous efforts to be made. The limited time of school science teaching hours imposes a strict assessment of science concepts to be taught. In such a way, students would assimilate these concepts and acquire the necessary framework of science knowledge, which will enable them later to understand more complex scientific theories, as well as to enjoy the peculiarities of scientific thinking. But, the educators and the curriculum designers have often proved unable to evaluate concepts of science that should be taught in primary and secondary education and they continuously try to include in science curricula as many science concepts as possible. This practice has forced students to memorize the final results, instead of studying the process of the syllogisms that led to those results (Arons1990).
- *The icons, the images, the simulations, the metaphors, the models and every kind of effort to bring the functions of an unseen world closer to our experience:* One of the main aims of science education is to make students able to construct a firm conceptual framework, which would help them to understand the way natural phenomena function. Thus, the educators try to create communication channels with stu-

dents' cognitive schemata; they try to find ways to make the functioning of invisible physical phenomena (microcosm, macrocosm) easily accessible to students' senses and experiences. But sometimes, these representations can create misinterpretations in the student's mind, or displace their interest to elements irrelevant to science concepts (Halkia et al 1998).

- *Teachers' notions and attitudes towards science and the teaching of science:* Many teachers have a limited knowledge of the didactics of science and they automatically repeat practices of the past (Halkia 1999). On the other hand, in science classrooms, teachers are trying to verify their status as scientists–researchers, denying their status as teachers. Their educational practices are confined to the utilization of a strict mathematical formalism interspersed with some empirical efforts of science popularization. Thus, they are trying to balance between practices of codifying science knowledge and techniques of solving exercises on one side, and efforts to help students to construct a firm conceptual framework on the other.
- *A lack of correlation between the teaching of science theories and the "authentic" problems of the physical world encountered in everyday life:* One of the main issues in science education is the achievement of problem solving in science classrooms (Dushl 1999). The problem–solving process is not an easy task; it demands strenuous efforts and mental discipline from students. That is why students are involved in such a process, only when it seems "meaningful" to them. For students, "meaningful" problems are those which are directly correlated with everyday life. These kinds of problems they consider as "authentic" and as worthwhile to be engaged in and to solve (Whitebread 1997). But, since the problems of everyday life are quite complex and are dependent by a number of components, the educators are forced to limit the number of these components in order to make them easily managed by the students in the science classrooms (Gott and Mashiter 1994). Such an approach makes these problems much easier for students, but at the same time it makes them unrealistic, less attractive and meaningless to them.
- *The historical development of the rhetoric and the concepts of science do not necessarily follow the mental development of students:* For some time it has been believed that the way the concepts of science are assimilated by school students is similar to the way these concepts have been constructed. For this reason, most science curriculums and textbooks follow the historic evolution of science concepts. But as recent researches show, the historic course of the construction of science concepts must not be taken for granted when these concepts are going to be exposed in primary and secondary education (Seroglou and Koumaras 2001, Nersessian 1994, Thagart 1992). A reason for that is that the historic evolution of science knowledge did not follow a linear mental course, but in many cases was dictated by necessities of the corresponding historic period, like technological potentialities, social requirements, cultural traditions etc. On the other hand, students do not necessarily possess the same mental skills and the same conceptual representations of

the world as the scientists of the corresponding historical period did. Thus it might be much easier for them if the scientific knowledge was to be presented in a more structured form. Maybe the designers of science curricula should propose a reconstruction of the historical conceptual sequence of science to be taught in schools.

COMMENTS

As has been above exposed, the transformation of the knowledge of science into school knowledge is faced with a series of hindering factors. Maybe these factors are the cause of the students' inability to enjoy the subject of science, to follow the syllogisms which lead to the understanding of the functioning of the natural world, and to gain the necessary science knowledge which in future will distinguish them as scientifically literate citizens. The peculiar thing is that while the negative attitude of students towards science is a common experience in science classrooms, everybody takes it for granted because of a long teaching tradition. On the contrary, we too easily blame students themselves for their negative feelings towards science, attributing these feelings to their indifference, to their social values etc. At the same time, the majority of the educational community seems to have been relaxed in routine– practices of the past, which are in favor of a linear accumulation of "knowledge–information" in the subject of science. It seems to be the right time now to face the difficulties mentioned above and to dare radical solutions in primary and secondary science education. But in applying innovations in science classrooms, the willing participation of the educational as well as the scientific community is needed.

Thus, it is necessary to explore alternative ways of approaching the scientific way of thinking. We believe that the absolute minimum of science education should result in all students leaving school with positive attitudes towards science. In achieving that we should try to offer them a variety of ways of exploring science. These ways would refer to different codes of communication suitable for different student personalities and interests. But in doing this we need the aid of the researchers in science education, as well as much more flexible science curricula.

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Reducing Gaps in Physics Communication by Metacognitive Questioning

Adina Koch, Hebrew University of Jerusalem, *adko@shum.huji.ac.il*
Nicos Valanides, University of Cyprus, *nichri@ucy.ac.cy*

INTRODUCTION

Some of the common gaps in physics teaching / learning are those between students and teachers' explanations or between students and physics texts. These gaps are so great that sometimes the lack of communication makes the teacher's explanations or the text read like students' "enemies". To improve this communication process it is possible either to improve teachers' explanations or texts, or to improve students' ability to comprehend them. Although it is very important to improve teachers' explanations and textual material, college students will also need to comprehend poorly presented lectures or poorly written material in their future independent work, because they have no option of changing them. This makes it essential to find methods of improving the students' communication skills. In order to reduce the gaps between students and teachers' explanations or physics texts, we investigated ways to make "peace" between these "enemies", encouraging the students' first step towards their "enemies" (teachers' explanations or texts): students' communication skills.

In daily teaching it is found that two kinds of students have difficulty in understanding teachers' explanations or physics texts: the over–optimistic students think that they understand everything, while the over–pessimistic students think that they understand nothing. Both types of students are not aware of their own condition of knowledge. Over–optimism and over–pessimism belong to "about self" belief systems that are subconscious determinants of an individual's behavior, determinants that are "beyond the purely cognitive" (Schoenfeld, 1983). The fact that an individual is unaware of having certain beliefs makes the beliefs more intractable: the more that one is aware of the factors that "drive" one's behavior, the more potential there is for changing that behavior for the better. Belief systems can be modified if one becomes aware of them.

One of the communication skills is the questioning skill. Generally, teachers tend to solicit answers from their students rather than to encourage questioning.

Student Question Formulation

Questions, when initiated by students, can contribute to the development of comprehension skills, whereas teacher initiated questions are used either as a teaching technique or as a test of knowledge. Questions formulated by students differ from those initiated by teacher. This is mainly because the teacher assumes that the students share common problems, ignoring the fact that different students have different views of a problem and might therefore ask different questions. As Osborne and Wittrock (1985) note, science learning and comprehension require that students, like scientists, ask questions about the ideas of others and about their own ideas.

Dillon (1988) points out that in asking questions, teachers, authors and testers are not searching for knowledge. On the other hand, the students, whose task it is indeed to search for knowledge and comprehension, do not have the habit of asking questions. In the standard classroom there is no mechanism for forcing students to ask questions whereas there is a powerful mechanism for encouraging the student to give answers. Student's answers are therefore passive and question dependent. It is the teacher's task to transform the classroom into a place that encourages the initiation of questions.

METHOD

Strategy

A metacognitive strategy was developed to improve students' communication skills, which we call the Question Formulation strategy. Metacognitive behavior is used to check, monitor, test reality, coordinate and control a deliberate attempt to execute a learning activity. Metacognition is a hidden level of behavior, which is focussed on conscious knowledge about knowledge and its relation to intellectual performance.

The Question Formulation strategy stimulates students' awareness of their difficulties in science communication and can be used by students as a self–monitoring technique to improve their communication. In this metacognitive strategy we developed students learn the skill of formulating questions; they learn to summarize the teacher's explanations or a physics text by formulating questions. Students are asked to formulate questions of three types about the teacher's explanations or about the given text: questions whose answers they understand (first type), questions whose answers they do not understand (second type), and questions related to teacher's explanations or to the given text, but whose answers are not found in either (third type). This is in agreement to Koch and Eckstein (1993) and McCormick (1992) which found that one cause for erroneous responses was readers' overgeneralization. Students were also instructed to write the answers to the questions of first type on a separate sheet of paper.

The question formulation strategy helps over–optimistic and over–pessimistic students as well. Using this strategy, the over–optimistic students find that they can formulate questions whose answers they do not understand, while over–pessimistic students find that they can formulate questions whose answers they do understand.

The advantage of the Question Formulation strategy is that students can use it as a self–monitoring device in later years to help themselves in their communication with scientific lectures or new texts.

Purpose

The purpose of the present study was to determine whether the practice of Question Formulation strategy could improve student's communication with physics texts and with physics teacher explanations or lectures, in order to recover better meanings from texts or lectures.

The hypotheses in this study were:

1. Practice of question formulation strategy can improve students' communication with teacher's explanations or lectures,
2. Practice of question formulation strategy can improve students' communication with the physics text they read.

Procedure

The sample consisted of four classes randomly assigned to experimental and control groups. These were college students studying a long year course of introductory physics. Two of the groups were tested for lecture comprehension: the first group, we called LE (Lecture–Experimental) containing 26 students, was tested for comprehension after eight weeks of treatment by students' question initiation about lectures presented. The second group, we called LC (Lecture–Control) containing 35 students, was tested at the same time, but during the same period of eight weeks they practice just a conventional answering technique to questions initiated by teacher after the lecture.

Other two groups were tested for text comprehension: one of them, we called TE (Text–Experimental) containing 28 students, was tested for comprehension after eight weeks of treatment by students' question initiation about texts they read. Another group, we called TC (Text–Control) containing 29 students, was tested at the same time, but during the same period of eight weeks they practice just a conventional answering technique to questions initiated by teacher about the texts they read.

These tests were of true–false comprehension type about the lecture or text students had to comprehend.

Results

It was found that the communication ability of the experimental groups was significantly improved over that of the control groups. As shown by table 1, the mean score of student's performances in experimental group was higher than in control group, for lecture comprehension.

Table 1. Mean scores and standard deviations for groups in lecture comprehension and their t– test

Group	Mean	SD	t (p)
Experimental (LE (n = 26)	70	20	2.5 ($p < 0.05$)
Control (LC) (n = 35)	54	27	

The variability in experimental group was smaller than in control group.

A t–test was carried out between the mean scores of the two groups. It shows a t–value of 2.5, with a significant $p < 0.05$.

Mean score of student's performances in experimental group was higher than in control group, for text comprehension, as shown by table 2.

Table 2. Mean scores and standard deviations for groups in text comprehension and their t– test

Group	Mean	SD	t (p)
Experimental (TE) (n = 28)	63	21	3.7 ($p < 0.001$)
Control (TC) (n = 29)	42	21	

A t–test was carried out between the mean scores of the two groups. It shows a t– value of 3.7 with a very significant $p < 0.001$.

Conclusions

The question formulation strategy was developed in order to improve the communication skill of college students in introductory physics. The strategy consists of a method in which students learn a self–monitoring technique for metacognition.

The study shows that it is possible to improve students' communication in physics by means of the question formulation strategy.

Question formulation changes the unrealistic belief system of students with respect to their communication ability, by making them aware of the state of their understanding, i.e. it enhances their metacognition. This is done by training students to differentiate between what they understand and what they do not understand.

Students have to be active involved in their own learning and they have to accept a major responsibility for it. The question formulation strategy gives students the active role of initiating and formulating their own questions and thus the problem of gaps in science communication is transferred from the teacher's responsibility to students' responsibility. The students become active monitors of their own state of comprehension. This method can later be used by students in their independent reading or understanding of scientific lectures, to increase their comprehension without tutorial aid.

Implications for preparing future citizens.

It is suggested that the Question Formulation strategy should be applied to topics other than physics, such as peace education in future citizens. In order to reduce gaps in communication between two "enemies" in a controversial problem, both sides have to be asked to formulate questions related to the problem and to place them in a metacognitive table of three columns, and not to leave any column empty: in column 1 – questions about something with which you agree in "enemy's ideas"; in column 2 – questions about something with which you do not agree in "enemy's ideas"; column 3 – questions related to the controversial topic but which don't belong to your or your enemy's positions.

While initiating questions in column 1, students become aware that they have agreed with some parts in their "enemies" positions. By separating questions in column 1 from those in column 2, students learn to distinguish between what they agree within the "enemies' positions" and what they do not. By separating questions in columns 1 and 2 from those in column 3, students learn to distinguish between what is stated in their and "enemies" positions and what is not. By separating questions in column 2 from those in column 3 students learn to identify the cause for their lack of communication: is it belonging to a failure in agreement or is it beyond the expressed positions of both?

By performing this metacognitive task students become actively enrolled in the communication problem and learn to transfer problems from "others'" responsibility to their own responsibility, becoming active monitors of their own state of communication.

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"Scientific (and Technological) Literacy for All: Presentation of a Research Model and an Attempt to Constructing a Relevant Proposal"

Karidas A. and Koumaras P., Aristotle University of Thessaloniki, Greece.
karidas@eled.auth.gr, koumaras@eled.auth.gr

1. INTRODUCTION

In recent years the demand that science education be accessible to all citizens is an increasingly gaining voice. Governments, international organizations (UNESCO, IOSTE, ICASE, ICASL, ESERA, WOCATE, GASAT etc.), authorities in science education and scientific journals seem to jointly promote the idea of "Scientific (and Technological) Literacy for All" (STL). In this paper, joining our voice with the global debate, we present a research model – the *ICMAS* –, which serves as a framework for the design and study of "STL" proposals. Furthermore, we try a small–scaled comparative study of some international "STL" proposals – including our own proposal – attempting to identify common features as well as differences.

2. ICMAS: A RESEARCH MODEL

In order to develop a "STL" proposal we have designed the *ICMAS* model, which can serve as a general framework for the design and study of "STL" proposals. ICMAS is an acronym made up of the words: *Ideology, Content, Modification, Assessment and Surroundings* (the core axes of the model).

PRESENTING THE ICMAS MODEL.

The model revolves around five axes (table 1):

1. The ideological axis: This axis is reflected in the general aims of the "STL for all" proposals and contains the arguments (in our opinion ideologically rooted) attempting to answer the question "Why?" – or otherwise, what reasons are there for making science and technology an imperative of our educational effort? We have recorded a series of arguments such as: a) the *economic* argument: A continuing supply of qualified scientists and multi–skilled workers is necessary to maintain the technological infrastructure and develop innovation and research (Millar 1996, Bevilacqua & Gianneto 1996). b) The *democratic* argument: Science and technology education can help citizens understand scientific reports in the media, contribute critically in public

debates, as well as participating actively in addressing socio–scientific issues (Driver et al 1996, Sjoberg 1997, Osborne 1999). c) The *ecologic* argument: A functional scientific and technological literacy would help citizens show responsibility for the environment and life, as well as, promoting the idea of sustainable environmental development (UNESCO's project 2000+, Canadian: Hereinafter 1995). d) The *cultural* argument: Science has changed our "world view" throughout the ages and has contributed in the way we think, philosophize and behave. Therefore, emphasis should be given on the relationship between science and culture (Millar 1996). e) *Positive Attitudes towards Science* argument: Science and technology are not exclusively "evil" enterprises, largely responsible for society's problems. Both have contributed in civilization in a way that has made our lives been easier and more comfortable. f) The *moral* argument: Scientific community is characterized by its ethics – ideals, norms and commitments – which could be of wider social value (Driver et al 1996). g) The *practical* argument: We all live within a scientific and technological environment. Therefore, scientific knowledge would be necessary for coping with aspects, issues and problems of everyday life (Sjoberg 1997). h) The *personal development* argument: Science Education could promote students' independent and higher order thinking skills as well as equip them with aesthetic and humanistic values (Holbrook 2000). i) The *personal fulfillment* argument: The tour of the amazing world of science might offer the voyagers emotion, excitement and wonder. Been well educated in science can contribute to a wealthy use of leisure time, meaningful explanations about the terrestrial and celestial phenomena and satisfactory answers to crucial philosophical questions – such as life and death, perception and reality, causality and probability etc. (Osborne 1999).

It should be noted also that in all the literature, including the arguments above, counter arguments also exist (see: Sjoberg 1996, Osborne 1999).

2. The content selection axis: This axis refers to the selection of content to be taught. In our view, the selections may be based, explicitly or implicitly, on the arguments of the ideological axis and possibly on students' subject interests. Arguments from the Philosophy, History and Sociology of Science could also contribute to the final selections of this axis. Regarding this axis we discriminate between a) the cognitive domain (general thematic topics area, elements of scientific methodologies area, students' alternative ideas area) and b) the metacognitive domain (nature of the diverse fields of knowledge area, science and technology in relation to other human endeavors, student's alternative ideas area) (table 1).

3. The content modification for didactical purposes axis: This axis refers to the educational reconstruction of the content for teaching and learning purposes (i.e. the choice of didactical methodologies and the development of suitable didactical tasks) and is comprised of the following domains: 1) Modes of Content presentation domain (e.g. Historical episodes, Science of real – life issues etc.), 2) Techniques of content negotiation domain (e.g. Designing & performing experiments), 3) Ideas communication domain (e.g. Poster display, oral presentations etc.) and 4) Teaching materials and

resources domain. When preparing suitable didactical tasks and students' activities, various factors can be taken into consideration such as teaching and learning theories, students' interests, modes of everyday language etc. Some cases of implication could be the following: a) teaching the science of everyday life, b) teaching science as the "game of wonder" – experiments using common objects, with unexpected outcomes, c) usage of narrative stories, d) presentation of the major steps in the history of science, e) presentation of the life of scientists etc. Information taken from the Sociology of Education as well as the Cognitive Psychology can contribute to the final selections of the axis.

4. The assessment axis: In this axis, we have to answer to the crucial questions: 1) what to be assessed? and 2) what assessment techniques might be used. The selections might depend on the decisions made on the ideological axis level as well as on choices adopted for the didactical methodologies and the teaching and learning activities made on axis 3. The assessment can be made in a summative way (by evaluating students' knowledge and skills) or in a formative way (by taking into account students' progress, by assessing students' collaborative work outcomes, or their social, sensory–motor skills and attitudes).

5. Didactical Surroundings axis: This final axis has to do with the various didactical surroundings that support the general instructional task, taking place in schools. Domains referring to this axis could include (table 1): 1) Students' role, 2) Teacher's role, 3) The classroom settings, 4) Informal learning resources, 5) School–society interplay, 6) Governmental support etc. Selection made on believes about teaching and learning theories, as well as, the way school and society interplay, might play a major role in the final adjustment and/or manipulation of didactical surroundings.

The key concept of any STL proposal according to our model is: consistency. This means the overall selections referring to the five axes of the model should not be at odd – on the contrary, must constitute a consistent and cohesive set of proposals, reflected on the initially declared educational aims (1st axis).

3. IMPLEMENTING THE MODEL

a) Constructive principles of a new STL proposal.

In order to develop a new STL proposal – by implementing the ICMAS model – we have adopted some fundamental constructive principles. These principles represent some of our general ideological positions regarding science education and citizenship. These principles are as follows:

☐ *Integrated worldview*: The World is a cohesive entity, a continuum of actions and events. An innovative science education should promote an integrated worldview by incorporating philosophical, historical, and social dimensions of the disciplines as well as dimensions of the various ways in which science and technology are related to other disciplines, say i.e. Maths, Humanities, Cultural Studies, Arts etc.

☐ *Active citizenship*: Students as future citizens should be active members of society, striving to uphold the values and ideals of real democracy. More explicitly, they should help each other, and actively participate in debates and actions related to vital socio–scientific and environmental issues, so as the vision of sustainable human and environmental development be achievable.

☐ *Respect to multi–culturalism*: The scientific and everyday ideas are usually controversial. An innovative science education should not abandon or marginalize students' cultural background – rather should enrich students' everyday way of living as well as help cope with the problems of everyday life.

☐ *Prosperous personal development*. A modern education should contribute to enrich students' personal development. In so doing, students' alternative ideas should be taken into serious account as well as their specific age interests, expectations and aspirations. This may make education a more interesting, and attractive enterprise, which in turn might lead students to a more wealthy and prosperous development.

b) A content selection (STL) proposal

We have chosen to initiate a STL proposal regarding only the *Content Selection Axis* (2nd axis). We are looking at extending the proposal including the remaining four axes in the future.

Regarding the *content selection*, we suggest the following subjects to be included in the *General Thematic Topics* area (Table 2): The Physical World (Physical Science, Life Science, Earth & Space Science), The made World, Aspects of the Mathematical World, The Human Society, Culture & Subcultures and Unifying Concepts and Processes in Sciences. These subjects have been selected for the following reasons:

☐ We, as human beings, live within a natural world as well as within a man made world. At the same time, we live within a multi–culturalized society.

☐ An aspect of the world of Mathematics works out to be necessary for the understanding of the relations between variables as well as presenting and processing data.

☐ And, a series of unifying concepts and processes in Sciences might be a good idea in order to promote an interdisciplinary approach to Science Education.

Furthermore, as we consider, an integrated science education should take into serious account the student's alternative ideas (Table 2).

The *Elements of Scientific Methodologies* (Table 3) have been selected so as they reflect on some fundamental components of scientific research. These are as follows: Identifying Problems, Asking Questions & Forming Hypothesis, Designing & Conducting Experiments, Making Observation, Calculation & Manipulation, Collecting, Processing & Interpreting of Data, Development of Claims & Explanations Based on Data, Students' Feedback & Metacognitive Awareness.

In turn, in the Metacognitive Domain we incorporate the following areas (Table 4): Nature of the Diverse Fields of Knowledge (Nature of scientific content & methodologies, Nature of Technology, Nature of Mathematics), Science in Relation to Other Human Endeavors (STS Interdependence, Science & Gender, Science–Non–science–Arts–History–Humanities relationship) and Student's Alternative Ideas area.

We believe that the above selections largely foster the idea of an integrated world-view as well as the science–technology–society–history–culture interrelation.

c) A comparative study

In the last few years, we have witnessed a series of "STL" proposals. Very well known among them are the American *"Project 2061"* and *"National Science Educational Standards"*, the Canadian *"Scientific Literacy in Canada: Hereinafter"* as well as the English *"Beyond 2000"*. In a comparative approach of the above proposals – including our own proposal – the following documents have been studied:

- ENGLISH PROJECT (1998): *Beyond 2000: Science education for the future.*
- AAAS (1989): *Project 2061. Science for All Americans.*
- AAAS (1993): *Project 2061.Benchmarks for Science Literacy.*
- AAAS (1998): *Project 2061.Blueprints for Reform.*
- NRC (1996): *National Science Education Standards.*
- CANADIAN PROJECT (1995): *Hereinafter.*

The research findings – regarding the 2nd axis of ICMAS model – as well as a few comments on some interesting points will be presented next.

The content development findings.

The findings according to the 2nd axis are presented in Tables 2,3 & 4. It is evident that particular emphasis has been given on thematic areas and topics such as: The Physical World, The Made World, Aspects of the Math world, Unifying Concepts and Processes in Sciences, Elements of Scientific Methodology, Nature of Science, Science–Technology–Society interdependence.

On the other hand, there seem to be but little or any emphasis on areas and topics such as: The human society, Nature of Math, Nature of Technology, Student's Alternative Ideas, Student's Feedback & Metacognitive Awareness as well as, Science–Non–science–Arts–History–Humanities relationship. In our view, these areas and topics should be taken into serious consideration, if we want to promote a realistic and attainable "STL for All" proposal.

4. EPILOGUE

The main issue evolving from our analysis is that the designing and developing the idea of "STL for all" is a particularly demanding task, which has to satisfy a number of fundamental principles along the five axes described above. Such principles should allow us to make selections about 1) *Why* science and technology should be imperative in our educational effort, 2) *what* should be included in a "STL for all" proposal, and 3) *how* it will be implemented and assessed. In any case, the crucial question being: *«what kind of citizens do we need for present day and future societies?»*

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Table 1. The ICMAS model

AXES	DOMAINS	AREAS
1. Ideological Axis	1. Good Arguments for STL 2. Counterarguments	
2. Content Development Axis	1. Cognitive	1. General Thematic Topics 2. Elements of Scientific Methodologies 3. Student's Alternative Ideas
	2.Metacognitive	1. Nature of the Diverse Fields of KnowledgeSelection 2. Science in Relation to Other Human Endeavors 3. Student's Alternative Ideas
3. Content Modification for Didactical Purposes Axis	1. Modes of Content Presentation 2. Techniques of Content Negotiation 3. Ideas Communication 4.Teaching Materials & Resources	
4. Assessment Axis	1. What to Assessed? 2. Techniques of Assessment 1. Classroom Settings 2. The role of Students	
5. Support Surroundings Axis	3. The role of Teacher 4. Informal learning Resources 5. School–Society Interplay 6. The Governmental Support 7. Others …	

Table 2. Content axis: Cognitive Domain (General Scientific Topics & Student's Alternative Ideas)

AXIS II CONTENT DOMAINS	AREAS	*ENGLISH Beyond 2000*	*USA 2061*	*USA Standards*	*CANADIAN Hereinafter*
I. Cognitive	General Topics Area The Physical World	+	+	+	+
	The Made World	+	+	+	+
	Aspects Of the Math World	+	+	+	—
	Human Society	—	+	—	—
	Culture & Subcultures	—	—	—	—
	Unifying Concepts And Processes in Sciences	—	+	+	+
	Student's Alternative Ideas	—	—	—	—

Table 3. Content axis: Cognitive Domain (Elements of Scientific Methodology)

AXIS II CONTENT DOMAINS	AREAS	*ENGLISH Beyond 2000*	*USA 2061*	*USA Standards*	*CANADIAN Hereinafter*
I. Cognitive Domain	**Elements of Scientific Methodology**				
	Identifying Problems	+	+	+	+
	Asking Questions & Forming Hypothesis	+	+	+	+
	Designing & Conducting Experiments	+	+	+	+
	Observation, Calculation & Manipulation	+	+	+	+
	Data Collecting, Processing & Interpreting	+	+	+	+
	Claims & Explanations Based on Data	+	+	+	+
	Feedback & Metacognitive Awareness	—	—	—	—

Table 4. Content axis: Metacognitive Domain

AXIS II CONTENT DOMAINS	AREAS	*ENGLISH Beyond 2000*	*USA 2061*	*USA Standards*	*CANADIAN Hereinafter*
2. Meta–Cognitive Domain	**Nature of the Diverse Fields of Knowledge**				
	Nature of Science (content & Methodologies)	+	+	+	+
	Nature of Technology	—	+	—	+
	Nature of Math	—	+	—	—
	Science in Relation to Other Domains of Knowledge				
	STS Interdependence	+	+	+	+
	Science & Gender Dimension	—	—	—	—
	Science–Non–science–Arts–History – Humanities relationship	—	—	—	—
	Student's Alternative Ideas	—	+	—	—

Experiments and Reflective Learning

M. Bandiera, "Roma Tre" University, Roma, Italy
(bandiera@bio.uniroma3.it)

M. Vicentini, "La Sapienza" University, Roma, Italy
(Matilde.Vicentini@roma1.infn.it)

1. INTRODUCTION

Science education is currently witnessing a change from a teaching approach aimed at the learning of facts and theories to one aimed at raising, confronting and solving problematic issues (Boud & Feletti, 1991; Watts, 1994; Gallangher et al, 1995; Peterson & Treagust, 1998; OECD, 2000).

Accordingly, a major change would be required precisely in the presentation of experimental activities in the general context of university science courses (lectures and laboratories) (Roth, 1995; Leach & Paulsen, 1999). In any case, direct contact with experimentation is obviously necessary in order both to familiarise students with the phenomenological aspects related to models and theories as well as to raise issues concerning the nature of science.

The same prospective would require that the experiment be presented in a problematic way so that the students are encouraged – forced – to think (Bandiera, 1999; Psillos et al, 1999). Discussion is an essential part of this didactic approach and, therefore, group work activities would be planned (Barnes & Todd, 1995; Bolte, 2001).

In the context of University courses specifically aimed at initial science teacher training, the laboratory activities – required in the curriculum – acquire increased value as an opportunity:

- for joining didactics to didactic research and for exploring from one year to the next, encounter by encounter, the students' knowledge and competence (without wasting time with constant, periodic tests);
- for placing on a lower level overused technical/methodological training and simple physical contact with objects and events in favour of the setting up of and training in productive modalities for recalling theoretical knowledge and pulling out data from the same objects/events;
- for taking into account not only educational objectives but also the multiplicity of intelligences, of cognitive approaches and of basic disciplinary competence (White, 1994).

The present investigation considers two ways of carrying out lab activities: the "demo–show" when the teacher, interacting with a large group of students, variously alternates actions related to an experimental procedure, interventions as facilitator, and provocation in order to enliven the discussion; the "lab–party" where small groups of students (from 4 to 6) sit at a "set" table and, taking advantage of a pre–structured form, follow an itinerary of experimental and reasoning steps. The "demo–show" proved to be particularly profitable for the prospective secondary school science teachers, who have degrees in a scientific discipline; the "lab–party" to the prospective primary school teachers who, coming from different secondary schools, have in common a generalised inexperience in science.

Both strategies require an appropriate choice of experiments which, in any case, must include the possibility of asking questions, thus activating and illuminating the students' knowledge and mental representations.

The experiments we plan to present focus on ice–cubes melted over conducting and insulating supports, containers with various quantities of fillings, rolled down a sloped plane, and human respiratory and pulse frequency modifications as a result of muscular strain. They have in common the characteristic of being related to some known phenomenology of everyday life. Therefore, when asked to explain or predict the experimental occurrences and outcomes, the students tend to adopt intuitive or semi–intuitive explanations/predictions that totally or partially conflict with the behaviour of the phenomenon when it is watched or performed. Such a contrast stimulates the discussion and the reflection on conceptual aspects.

Section 2 illustrates an experiment carried out in the two methodologies. Two other examples, a "demo–show" experiments (sec. 3) and a "lab–party" experiment (sec. 4), are presented.

2. THE ICE CUBES EXPERIMENTS

The "demo–show" starts with the request for a prediction of the difference in the time needed for two ice–cubes to melt, one placed on a conducting sheet and the other on an insulating one. The dimensions of the sheets exceed that of one face of the ice–cube. While at secondary school level in general a fraction of the students (nearly 1/3) predict that the cube on the insulating surface will melt first, at a higher school level nobody doubts that it is the ice–cube on the conducting sheet which will melt first, but the time difference is always underestimated (from 5 minutes to half an hour). Some students (with degrees in scientific disciplines and enrolled in initial teacher training course) unfailingly try to avoid an answer by pointing out that the question is not well formulated as some data are missing, such as the temperature of the cubes and that of the environment, and the dimensions of the sheets. However the sheets are in front of them, and it would be very easy to estimate (or measure) the two temperatures. (Again, it may come out with secondary school students that the temperature of ice is undoubtedly 0°C.) Then the experiment starts and the students are asked to observe carefully, while a discussion on the developing process and on the variables needed to describe it takes place. After a quarter of an hour, with the ice cube on the insulating sheet showing no signs of melting, attention can be suitably turned to the "behaviour" of the ice–cube on the conducting sheet. The discussion then brings in the possibility of reasoning in terms of conduction–convection–radiation, the need to focus on the thermal equilibrium of the cubes both with the sheets and with the environment, eventually the differences in the specific heats of the sheets in addition to the conductivity coefficients, and to what will happen if the dimensions of the sheets are changed.

In the "lab–party", due to the low level of prospective primary school teachers' competence in Physics, sensory contact with the materials opens an activity which has to be completed in the nine steps listed in the form and in appendix 1 (together with a synthetic collection of data taken from the filled forms).

The majority of the 76 students attribute very different temperatures to the aluminium and polystyrene sheets, which are placed in the same room, on the same table (step 2). They think that room temperature has the most relevant incidence on ice–cube melting time; some of them point out the material on which the ice–cube rests (reasonably due to their advance reading of the form).

The predictions about the ice–cube melting time when resting on a sheet (step 4) put in evidence three main conceptions concerned with the exclusive implication of room temperature, with the actual different temperatures of the sheets, with the conduction/insulation, and some related, well known (mis)conceptions about temperature, heat, heat diffusion, and so on.

After the melting of the cubes on the first pair of sheets (step 5), perplexity about polystyrene behaviour persists (due to the very long melting time). The aluminium sheets, on the contrary, seem to be assorted according to an experimental hypothesis in mind by at least half of the work groups (step 7); by way of confirmation, the reasoning for making predictions is clearly oriented toward heat conduction. 28 students seem to be tempted to deduce from the opposite *qualities* of polystyrene with respect to aluminium, an opposite behaviour (i.e. a direct proportional relation between size and melting time).

After the melting of the cubes on the second pair of sheets (steps 8 and 9), the weight of a correct explanatory attitude appears to have increased, and this result can only be attributed to collective reflective peer discussion on experimental outcome. (Some minor, anomalous implications, such as the "temperature of the support" and the roughness/smoothness of the surface, however persist!)

The itinerary concludes with a classroom analysis of (experimental and knowledge) data.

3. MORE ON "DEMO–SHOW" EXPERIMENTS: THE ROLLING CONTAINERS

Containers with different quantities of filling of the same material show a different movement behaviour: when rolling down a curved track they may approach the equilibrium position at the bottom after more or less dampened oscillations.

The experiment starts with the presentation of the material focusing on the complete external identity of the containers. When the motion is shown, however, some containers oscillate normally with a dampened amplitude while others rapidly reach (one or two oscillations) the equilibrium position. The students are then asked to provide an explanation of the different behaviours.

In the following discussion, of course, "friction" is cited for the dampening, but soon it is clear to all that the difference must be due to the different weight of the objects. Two positions then emerge: the different weight gives rise to a different force of friction between the surfaces of the containers and the slope (the majority of the students) or to some effect related to internal friction (a minority which also tries to hypothesise on the quality of the material inside the containers).

In all the demos (involving Italian student teachers, Chinese student teachers and researchers in physics education, Mexican researchers in physics education) the conceptual scheme invoked for the explanation is a "force scheme". The didactic strategy may then direct the attention, on the one hand, to the scientific methodology of getting information on the internal structure of an object by planning other experiments and, on the other, to search for a conceptual scheme more useful for the case. It is surprising that very few students express the need to resort to an "energy scheme" while all suggest the need for experimental data on the weight.

While this is recognised by the teacher as important information, students are asked to express predictions on the influence of the weight on the dampening rate. Such predictions are unanimous: the dampening rate has a linear relationship to the weight.

By hand weighing the objects, some students disprove the prediction: the dampening rate is maximum for some intermediate weights.

The explanation in terms of the external friction force is then abandoned in favour of an internal effect. Time is needed here for small group discussions which usually remain anchored at a "force scheme" also if the suggestion of measuring the inside temperature may be advanced.

This is a good step for the teacher to suggest the shift to the conceptual scheme of energy eventually focusing the difficulties of application of the "force scheme" to the case.

Energy, potential and kinetic energy… internal energy. The introduction, in relation to a mechanical phenomenon, of this concept which is seen as belonging exclusively to Thermodynamics, seems to come as a surprise for the majority of the students. They are then forced to reflect on the general application of the energy concept while disconnecting the "friction–heat–temperature increase" relation and conceptualising the "dissipation rate in the external motion–internal energy" relation.

It is not easy to report quantitatively the events in the discussion of a demo–show experiment and, in fact, it does not even make sense. Important quantitative information may only be related to the quality of the discussion itself. This is mainly related to the ability of the teacher in collecting important ideas in the interventions of the participants, while directing their attention and reflection on their own knowledge.

Discussions proved to be very lively while differing in their development according to the group of students. In conclusion some common key words could be suggested for reflection: first of all, energy (conservation and dissipation), the difference between the mechanical and the thermodynamical point of view on the same phenomenon, heat and temperature, the concept of time in mechanics and in thermodynamics, the atomic model of matter.

4. MORE ON "LAB–PARTY" EXPERIMENTS: PHYSIOLOGICAL REACTIONS TO MUSCULAR STRAIN

The experiment is dedicated to similarities and differences of individual physiological reactions (in terms of cardiac and breathing frequencies) to an increasing muscular strain. The main objective concerns production, reading and interpretation of graphs. The pre–structured form proposes six steps which are listed in appendix 2 together with a synthetic collection of data taken from the filled forms.

In the first step the range and the frequencies of the chosen terms indicate that students have an adequate basic knowledge of the topic. After performances are carried out and data collected, students draw graphs without manifesting those evident problems that instead emerge from group discussions about the description. The predominant procedure consists of singling out details from the graphs, thus data integration justifying graph elaboration is fruitless. As a widely shared mistake, the feature of the performer which was previously noted (steps 2, 3 or 4) is considered the direct cause of each peculiar modification in cardiac and breathing frequencies (e.g. "As far as the third member is concerned, his gym training makes the initial increase of his breathing frequency slight").

At step 6 personal, often unsupported, opinions are expressed as results rather than hypotheses; nevertheless many original, meaningful interpretations are read in the graphs and the experiment as a whole is incisively commented.

The final classroom discussion takes advantage of the concrete experimental situation, and of correct and creative explanatory contributions to emphasise necessary amendments and completion of the phenomenon analysis.

5. CONCLUDING REMARKS

Demo–show and lab–party activities specifically ask students for their explanation of phenomenological occurrences as a task or problem, recall of pertinent knowledge and conceptions, direct contact with events, involvement in a systematic analysis, reflective approach and peer negotiation. Results suggest that students gradually shift from prevailing common sense and vague positions, to scientifically substantiated ones. This allows for the supposition that a wider adoption of these activities in university science education (in particular, in initial teacher training courses) would help future citizens to make autonomous decisions about science and technology, rendering them open to appreciating and using innovation, but also to recognising its potential risks and, if necessary, to firmly refusing it at a personal and political level.

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Appendix 1

1. Touch the materials on the table. Write down three qualities of each one.
49 students write down qualities perceivable by touch (light/heavy; soft/hard; stiff/-warping; thin/thick; compact/porous; edgy, crumbly), 12 qualities perceivable by sight (white, lucid, glittering, reflecting), 8 both perceivable by touch and learned qualities (-conducting/insulating; sound proofing/reflecting; synthetic; compressed; ductile; floating), and one learned qualities only ("sound reflecting, conducting, specific weight higher than water; soundproofing, insulating, floating").

2. Indicate what you believe to be each one's temperature?
The temperatures which students attribute to aluminium and polystyrene sheets are presented in the following table (absolute frequencies shown):

	0°–5°	*6°–10°*	*11°–15°*	*16°–20°*	*21°–25°*	*26°–30°*	*36°–40°*
aluminium	13	22	10	20	11	–	–
polystyrene	–	–	9	30	33	1	2

The perceived differences in temperature of the two materials are summarised in the following table:

difference in temperature	*0°*	*1/5°*	*6/10°*	*11/15°*	*16/20°*
number of students	15	13	24	16	2

3. Now imagine taking an ice–cube out of the freezer: how long do you think it will take to melt completely? (Write down two of the reasons for making your prediction.)
34 students predict a melting time lower than 15’, 24 included between 15’ to 40’, 10 included between 45’ to 60’, 8 higher than 60’. The following reasons were considered for making the prediction: room temperature (69 students), volume of the ice–cube (15), material on which the ice–cube rests (36), and temperature of the previously cited material (4). Draughts, seasons (winter), shade and sun, environment, heat sources, water production, and temperature of the sheet were also indicated (24 students in all).

4. Now imagine placing one ice–cube on a sheet of aluminium and one on a sheet of polystyrene. How long will it take for each one to melt completely? (Write down two of the reasons for making your prediction.)

Predicted melting times of ice–cubes resting on sheets are presented, taking as a reference the melting time (mt) that students indicated at point 3, when they had to consider an ice–cube not resting on a sheet:

	on aluminium sheet	*on polystyrene sheet*
melting time shorter than mt	39	15
same melting time as mt	22	21
melting time longer than mt	14	36

In addition to synthetically formulated expected reasons, concerned mainly with conduction/insulation of the material, dimensions of the sheets (and room temperature), many meaningful and evocative reasons, emerging from detailed explanations, were collected (the asterisk marks favourite opinions):

- on aluminium, which gives off heat, the cube will melt in a shorter time
- aluminium, as a good conducting material, exchanges heat with ice
- aluminium which owns less heat quantity than polystyrene, will melt ice in a longer time
- *aluminium has a much lower temperature than room
- an ice–cube, in touch with a cold material (aluminium), will melt faster
- aluminium is smooth, therefore conducts
- due to its low specific heat, aluminium will hamper ice melting
- *since polystyrene is an insulating material, the melting time is due only to the room temperature
- polystyrene, being insulating material, delays ice melting
- polystyrene will melt ice in a longer time
- polystyrene blots, while aluminium is smooth
- polystyrene insulates the ice cube from room temperature
- polystyrene has a higher heat quantity to offer
- polystyrene keeps temperature of the objects with which is in contact
- *ice will melt faster on polystyrene since its surface is warmer
- *time depends on temperature of the object on which ice rests (the two materials have different temperatures).

5. Check your hypothesis, indicating which of the sheets you have chosen from among those available. Write down the resulting melting times.

6. Now choose two different sheets and, based on the data resulting from the above experience, formulate a prediction on melting times. (Summarise what you have based your prediction on.)
Students who work in a total of 16 groups (from 4 to 6 students each) had at their disposal a total of six aluminium square sheets (20×20×015, 20×20×01, 10×10×02, 10×10×015, 10×10×01, 10×10×005 cm) and four polystyrene square sheets (30×30×4, 20×20×2, 10×10×2, 10×10×1 cm).

The absolute frequencies of assortment of aluminium sheets are presented in the following table:

side length (cm)	*thickness (cm)*	*compared features*	*groups nr*
10	005/01	thickness	1
20/10	01	area	8
20/10	015	area	1
20/10	01/02	volume	1
20/10	01/005	volume	2
others		?	3

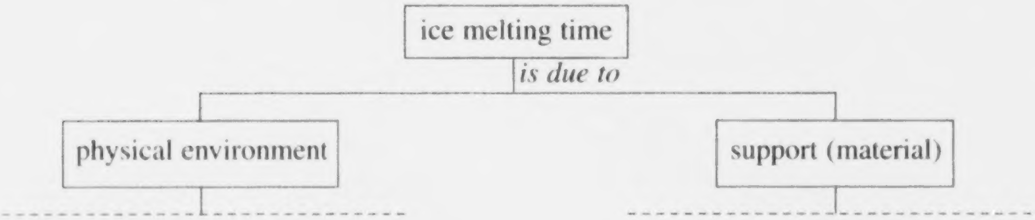
The reasoning about melting time takes into consideration the following arguments:

		aluminium	*polystyrene*
involved features	area	54	24
	thickness	29	4
	conduction	10	–
	insulation	–	20
manner	heat exchange	14	–
	heat loss	12	–
	heat absorption	4	–
	water production/expansion	3	–
size–melting time	inverse proportion	53	–
	direct proportion	5	28
	independence	11	18

7. Check your hypothesis, writing down the melting times on the second pair of sheets.

8. List five terms (or brief definitions) that you believe necessary in formulating a "scientific" explanation of the event that you have observed.
The following 360 terms – which are listed according with their frequency – are indicated: conductivity (61 students), insulation (49), material (44), room temperature (36), temperature (34), size (26), area (23), thickness (20), heat (19), time (12), width (10), temperature of the support (8), non conductivity (8), material features (6), and length (4).

9. Starting with the generating nucleus provided, expand the map so as to integrate the terms that you have listed in step 8 and, if possible, also the "qualities" you wrote down in step 1.



Map is expanded by adding at a first level under the branch labelled "physical environment" temperature (73 students) and room size and/or crowding (7). At a first level under the branch labelled "support" are placed conductor/insulating (62 students), size (24), smooth/rough (7), aluminium/polystyrene (6), composition (4), blotting/not blotting (4), and warm/cold (2). 3 students insert a third branch labelled "heat", intending "modalities of heat diffusion".

Appendix 2

1. List five terms that you believe necessary in explaining the main functional modifications of a – for instance, human – organism when it performs physical exercise.
84 students list a total of 428 terms which have been grouped according to represented processes:

breathing (breath, breathing frequency, breathlessness, out of breath)	89
blood circulation (pulse, heart beat, beats)	89
blood pressure (pressure)	8
muscular work (muscles)	69
energetic metabolism (energy consumption, lactic acid storage)	28
body temperature alteration	29
perspiration (gland secretion, salt loss)	78
weariness (stress, training, tiredness)	20
(unclassifiable or incomprehensible terms	*18)*

2. Measure pulse frequency (heart beats/minute) and breathing frequency (inhalations/minute) of a first member of your work group (and write down his/her gender, age, constitution, gym training): a) while resting, b) after going down and up a flight of stairs, c) after going down and up a second flight of stairs, d) after going down and up a third flight of stairs, e) after going down and up a number of flights of stairs (that you will write down) until he/she declares to be tired. Plot the data in the predisposed table and graph.

3. Repeat the sequence (point 2) with a second member of the group who differs from the first member in at least one of the considered features.

4. Repeat the sequence (point 2) with a third member of the group who differs from the first and second members in at least one of the considered features.

5. Analyse the three graphs and describe at least four aspects

- **which allow the correlation – in a general way – between the extent of the effort and the considered physiological parameters (similarity of graphs);**
- **which allow the formulation of hypotheses about the relevance of one of the considered individual features (similarity/difference of graphs).**

Students carry out the performance, collect data, analys graphs and take into consideration the following types of aspects:

correlation between muscular work and cardiac frequency[1]	38
correlation between muscular work and breathing frequency[2]	42
correlation between cardiac and breathing frequencies[3]	12
correlation between individual and graph features[4]	33
details of one of the drawn graphs (corresponding to one of the performances)[5]	157
details of drawn graphs (general features of the trends)[6]	31

Some examples: 1. "In general, the more strain increases, the faster pulse is." 2. "While starting motion, breathing frequency starts increasing." 3."The breathing frequency increases slower than beats." 4."The second and third members who are not gym-trained show a relevant increase of beats and breathing." 5."The member who started with the lower pulse, ended with the higher pulse and breathing frequency." 6."After a slight increase, breathing frequency tends to stabilise."

6. Explain at least one of the described aspects of the graphs, while singling out causes and consequences in terms of "good body functioning". If you think that you lack the needed scientific knowledge, express reasonable hypotheses, trusting your sense. Anyhow, verify the usefulness of terms listed at point 1.

Students write down, in addition to mere repetitions of observations (see point 5), outright explanations which were grouped according to interpretative attitude:

recovery and use of learned information (e.g. "Body, when under strain,needs energy. Both heart and breathing frequencies contribute to the supply of oxygen to the muscles.")	30
original interpretation of graph details (e.g. "In gym–trained people strain became natural performance, therefore frequencies did not leap, but gradually increased, and an early stabilisation occurred.")	34
original comments about the experiment as a whole (e.g. "It seems that each person activates a different strategy in order to cope with muscle demand.")	3
common sense comments, not justified by data (e.g. "Non–smoker shows lower physical resistance.")	12

Paints–A Way to Industrial Systems

L. Saar, M. Kesner, and Z. Scherz, The Weizmann Institute
of Science, Rehovot Israel, *ntkesner@wisemail.weizmann.ac.il*

BACKGROUND

In 1993 a new reform took place in Israeli junior high schools: a new subject "Science and Technology" was introduced followed by a new syllabus published by the Israel Ministry of Education in 1996 (Ministry of Education, 1996). The new syllabus encouraged the development of new integrated multidisciplinary curricular materials intended to gradually replace the traditional materials by combining scientific and technological topics. The new curriculum specifically emphasizes the development of student learning, inquiry and thinking skills. In addition to their exposure to content learning the students are taught to be literate citizens in modern society (Scherz & Spector–Levi , 1999).

The MATMON group of the Dept. Science Teaching at the Weizmann Institute of Science is one of two major bodies responsible for Science and Technology curriculum development in junior high school. The unit "Paints – a way to industrial systems", a new MATMON learning material, covers two major subjects (out of seven) in the new syllabus: "Materials – Structure, Properties and Applications" and "Technological Systems". Students, taking this program should have prior knowledge of the structure of matter (atoms, molecules, elements, compounds) and preferably also of simple technological systems. This unit introduces new contents related to chemical processes and industrial systems. The students should have prior knowledge of the structure of matter (atoms, molecules, elements, and compounds) and preferably also be acquainted with simple technological systems. This unit introduces new material related to chemical processes and industrial systems.

GOALS

- To gain knowledge and understanding of the interrelationships between science, technology, the environment and society in the context of the real industrial world.
- To gain knowledge and understanding of materials, mainly chemical reactions.
- To gain knowledge and understanding of simple and complex systems.
- To gain knowledge and understanding of industrial production systems in general and paint production in particular.

- To gain knowledge and understanding of scaling up problems and the connection between lab experiments and industrial production processes.
- To develop learning, inquiry, and problem–solving skills.

CONTENT

The unit deals with the production of paints and their applications including interrelated issues such as the chemistry of paints, environmental aspects, the quality of products and quality control, as well as the difference between lab experiments and scaled up industrial systems.

The unit is built around a story frame about a group of kids looking for a way to paint their club house. The story motivates the students to perform some experiments through which they study about the components needed to create paint. In order to investigate more thoroughly these components and the tasks involved the students are divided into three groups, each group investigating one out of the following areas: solvents and solubility, polymers, pigments, and colors. Through team work each group practices various learning skills, such as reading articles, surfing the internet, performing experiments, discussing issues of interest, and visiting related sites. Then the whole class participates in an additional activity in which they have to teach their field of expertise and then design together paint for a specific use.

After acquiring a basic scientific and technological background, the students move to "world of industry". First they experience scaling up technological problems by trying to prepare dough, starting with small amounts and scaling up to large amounts. This activity involves the use of flow chart descriptions for production processes in general, and paint production in particular.

From simple industrial systems the students progress to more complicated ones including control systems and systems that aid in maintaining the environment.

In the next part the students are divided again into groups of experts, this times regarding three new topics: quality and standards, environmental issues, and marketing. After another session of peer teaching in which each group of experts presents the main ideas of its area of interest, there is a concluding chapter dealing with additional general facts about the paint industry in practice.

SKILLS

In this unit the above material is integrated with diverse learning and teaching methods including group discussions, self–learning, cooperative teaching, role–playing, learning by inquiry of science and technology, and teamwork etc. Part of the learning is done outdoors. The students are also required to use different skills in carrying out tasks such as asking questions, collecting information through experiments, understanding experimental results, building models, searching for information in the internet, interviewing, and presenting information to their classmates in different ways, for example posters, transparencies, computer presentations, lectures and demonstrations.

IMPLEMENTATION AND FOLLOW–UP ACTIVITIES

In the first year teachers participating in a science and technology in–service course for junior high school were briefly exposed to the unit. One of the teachers chose to teach this unit in her class and we followed her experience through a feedback questionnaire given to the students, video taping the class during peer teaching activity, and interviewing a group of students. We also interviewed the teacher twice about her experience and about her future intentions regarding the unit, later using the information to improve different aspects of the unit. Additional information was given to us by another teacher in a different school who tried part of the unit in her class and gave us some of her impressions.

At the end of the year three more groups of science and technology teachers were introduced to the new unit in a short term (one–half to two days) in–service training course. Most teachers expressed their interest in the program and some were very enthusiastic. In fact some of them expressed their desire to teach it the following year.

PRELIMINARY RESULTS

During the first interview the teacher who had participated in the program told us that this unit enabled her to successfully demonstrate the integration between science and technology issues. She felt that the students showed great interest in the subject and told us about teaching methods. The next year, when she compared the class that studied this unit with another class of hers that did not study it the previous year, she could clearly see the difference. The students that had studied this unit had much richer background and understanding of the connection between science and technology, and importantly, they had better learning skills. She intends to organize a course on this topic for teachers in neighboring schools during the year.

The students who were interviewed by us reported that when asked to perform independent study they felt a responsibility, not only to experience it but also to teach others. The team teaching "forced" them to seek out better teaching methods, to concentrate on the main principles and the most important concepts within the subject, to choose the most convincing experiment and also to find a way to assess their success in teaching their classmates. The students expressed their enjoyment and interest in the unit and gave some advice regarding how to improve it. These comments were taken into consideration when rewriting the first edition. Some quotes from students` feedback questionnaires: " It was great", "This way of learning helps to enrich our knowledge", "This way of studying enables every member of the group to raise his or her own ideas", "My subject was very interesting".

More results will be presented in the lecture.

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A Study of the Way Science and Technology are Presented in the Greek Daily Press: Linguistic Codes,Visual Codes and Social Impacts

K. Dimopoulos and V. Koulaidis, University of Patras

1. INTRODUCTION

The aim of this paper is to investigate the relationship between the social impacts of Science and Technology as presented in the Greek daily Press with the linguistic and the visual codes employed.

The first reason for focussing our interest on the Press presentation of Science and Technology is the growing tendency of many science and technology courses to use Press material as a supplement to the core educational material used in an attempt to make these courses more relevant and more attractive to the students.

The second reason of our interest lies on the finding of many international surveys (Eurobarometer, 1993, Science and Technology Indicators, 2000) that Press is one of the most important sources of information of the Public for Science and Technology matters and hence it forms the socio–cultural climate into which both students and citizens perceive these two areas of human endeavour.

This kind of interests resonate with a growing interest during the last two decades, in the language and the visual codes of scientific texts of various genres varying from academic to popular ones. The reasons for the interest in this area are varied from socio–epistemic concerns to educational goals. In this paper the linguistic and the visual codes are considered as:

- Resources for meaning and
- Firmly related to the social context of each text.

Since the linguistic and the visual codes are not considered as a neutral means of transferring the message but on the contrary are considered as crucial factors formulating it, they are going to be examined under this perspective in this study. On the other hand it is assumed that the image of Press about the social impact of Science and Technology forms to a large extent the public beliefs and attitudes which in turn form the level of social acceptance of Science and Technology.

The examination of the relationship between the codes employed and the kind of the social impacts presented can provide us with a consolidated estimation about the suitability of the Press material as educational material and also about the prevailing image of Science and Technology formed by Press in the social arena.

2. METHODOLOGICAL FRAMEWORK

The variables corresponding to specific features of the articles' texts are grouped into three dimensions, which are defined so as to organize the analysis of the linguistic and the visual codes employed in the coverage of the social impacts of Science and Technology in the Press. These three dimensions as far as the linguistic code is concerned are defined as follows:

- *Emotional involvement*: by the number of emotional expressions included Such expressions produce strong interpersonal inducement and the readers' emotional engagement in the situation presented in each article.
- *Techno–scientific content and explanation*: by the number of: the isolated techno–scientific pieces of information, the techno–scientific concepts, the quantitative and semi–quantitative references per article, the expressions signifying causal relationships of the form 'a causes x' and the number of metaphors and analogies per article.
- *Formality of the linguistic code*: by the linguistic resources that construct the technicality and abstraction that characterizes the scientific language. These resources according to Halliday and Martin, (1996) are the number of: terms, verbs in passive voice and nominals or nominal groups per article and also the syntactic complexity of each article. The syntactic complexity of each article is defined as the ratio of the number of sentences with subordinated conjunction over the total number of sentences of the article. This dimension shows the level of technicality and abstraction of the linguistic code employed by each S&T article.

For all the above variables it has to be stressed that their values are standardized with respect to the total number of words of each article.

The three corresponding variables for the visual code are defined as follows:

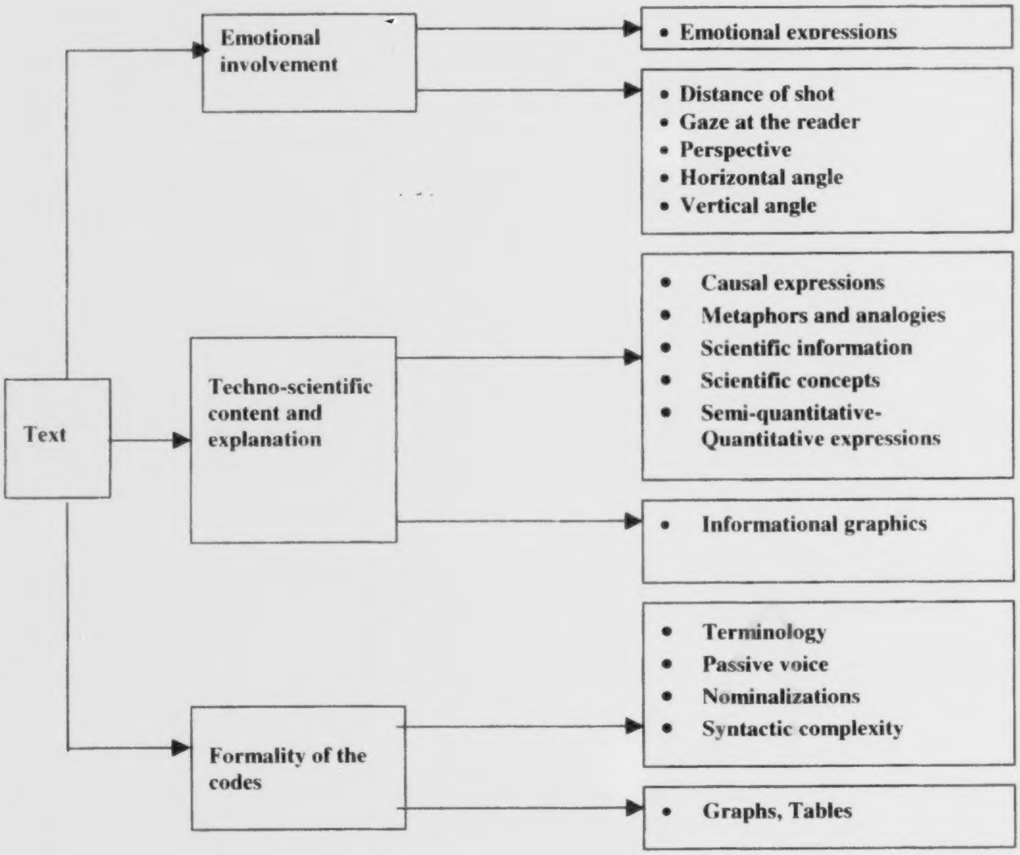
- *Emotional involvement*: by the distance of shot (e.g. close, medium, distant shot), the perspective (central, non central), the gaze or not of the represented participants towards the reader and finally the horizontal (frontal, oblique) angle of shot. The emotional involvement of the reader induced by the visual code is considered as increasing if the distance of shot is close, the perspective is central (which means that the main lines of the representation converge out of the illustration's frame hence allowing the reader a personal view of the represented participants), the represented participants gaze the reader and finally the horizontal angle of shot is frontal.
- *Techno–scientific content and explanation*: by the number of informational graphics per article. The informational graphics are defined as graphic representations of data, statistics or processes. Such graphics can be for instance pie charts, bar charts, line or fever chart plotted over time by a trend line, table–visual display of words or

numbers in columns, a map, a list–an item by item entry of persons or objects arranged in a certain order, or information in pictorial or diagram form designed to explain or define a relationship or process.

- *Formality of the visual code*: by the number of the visual illustrations that are not natural representations of reality (e.g. pictures, photographs, drawings) but use instead a coded scientific format to convey their meaning (e.g. graphs and tables).

The overall scheme of analysis of the linguistic and the visual codes of the articles is presented in the following diagram.

Diagram 1: The overall schem e of analysis of the linguistic and the visual code of the articles


Emotional involvement
• Emotional expressions
• Distance of shot
• Gaze at the reader
• Perspective
• Horizontal angle
• Vertical angle
• Causal expressions
• Metaphors and analogies
• Scientific information
• Scientific concepts
• Semi-quantitative-Quantitative expressions
Text
Techno-scientific content and explanation
• Informational graphics
• Terminology
• Passive voice
• Nominalizations
• Syntactic complexity
Formality of the codes
• Graphs, Tables

The second level of analysis of this study concerns the social impact of Science and Technology as presented in the Greek Press. These social impacts can be either:

- Positive, if Science and Technology are presented to produce beneficial outcomes (e.g. economic growth, access to information, improved safety conditions, etc) or

- Negative, if Science and Technology are presented to produce harmful outcomes respectively (e.g. ecological degradation, increased unemployment, threats on individual rights, etc).

There is, of course, a small number of articles presenting a mixed picture of Science and Technology as far as their social impacts are concerned. These articles though were assigned to one of the two above categories according to which kind of impacts seem more prevailing.

Our sample consists of 1867 articles concerning Science and Technology, which were selected from four Greek newspapers of large circulation and covering the largest part of the Greek political spectrum. For each newspaper they were randomly selected 28 days per year so as the sample to consist of 4 issues per newspaper and day of the week per year covered in this study. Using this sampling procedure the issues of each newspaper correspond to four 'constructed weeks' per year. The issues of the four newspapers examined, cover the period beginning from January 1996 up toDecember1998.

The text and the visual illustrations of the articles, were analyzed in terms of the three dimensions presented before. The relationship then between each one of the three dimensions of each code with the kind of the social impacts of Science and Technology was explored by the chi–square test.

3. RESULTS: PRESENTATION AND INTERPRETATION

The Greek Press, as shown in Table 1, seems to portray a generally positive image of Science and Technology as far as their social impacts concern.

Table 1: Kind of Social Impacts of Science and Technology in the Greek Press

Kind of impact	*Percent*
Negative	34.2
Positive	65.8

Below we present our findings concerning the three dimensions of the linguistic and the visual code respectively, employed by the techno–scientific articles in the Greek Press.

3.1 Emotional involvement

As shown in Table 2 the majority of the S&T articles use low emotionally charged codes.

Table 2: The level of the emotional charge of the linguistic and the visual code

Level of emotional involvement	*Percent (Linguistic code)*	*Percent (Visual code)*
Low	61.9	58.4
High	38.1	41.6

These findings are in sharp contrast with a usual accusation to the Press that it tends to overuse emotionally charged codes (e.g.Rowe, Frewer and Sjöberg, 2000), so as to present a sensational rather than a realistic picture of reality and by this way to capture the readers' attention.

3.2 Techno–scientific content and explanation

As far as this dimension of the analysis is concerned, as shown in Table 3 the majority of the S&T articles provide their readers with little techno–scientific content and explanation either through the linguistic or the visual code.

Table 3: Level of the techno–scientific content and explanation in the articles provided by the linguistic and the visual code

Level of the techno–scientific content and explanation	*Percent (Linguistic code)*	*Percent (Visual code)*
Low	69.5	82.5
High	30.5	17.5

It is shown that Press in most of the cases does not present the facts of the techno–scientific knowledge and their explanation. This picture has also been borne out by other content analyses (e.g. Pellenchia, 1997, Long, 1991). In the cases though that Press presents such kind of information this is mainly done through the linguistic rather than the visual code.

Therefore the S&T articles do not allow their readers to enter the cognitive territory of Science and Technology by providing them with a low quantity of techno–scientific content and explanation. Press then tends to black box Science and Technology making them opaque cognitive territories for the lay reader.

3.3 Formality of the codes

Finally most of the S&T articles employ a linguistic and visual code of low formality as shown in Table 4.

Table 4: Level of formality of the linguistic and visual code in the S&T articles

Level of formality of the codes	*Percent (Linguistic code)*	*Percent (Visual code)*
Low	73.9	85.6
High	26.1	14.4

The low formality of the codes used by Press allows the lay readers to have better access to the semantic content presented and is in contrast with the formality of the codes employed in other techno–scientific genres directed to lay–audiences and more specifically the school science textbooks.

It is also characteristic from the analysis above that in all three dimensions both the linguistic and the visual code function in the same way creating a picture of Science and Technology which can be described by low emotional charge, little techno–scientific content and explanation and low formality.

3.4 Study of Correlations

After the separate examination of the three dimensions of the linguistic and the visual code of the S&T articles in our sample the relationship between the linguistic and the visual codes employed and the type of the social impacts presented was studied using the chi–square test. The levels of statistical significance are shown in the Table 5 below.

Table 5: Statistically significant relationships between the type of the social impacts of Science and Technology and the three dimensions of the linguistic and the visual code respectively

Dimension of the codes/ Type of social impact	*Linguistic code*	*Visual code*
Emotional involvement/ Type of social impact	Significant at p<0.0001	
Techno–scientific content and explanation/ Type of social impact	Significant at p<0.033	Significant at p<0.014
Formality/ Type of social impact	Significant at p<0.007	Significant at p<0.002

As shown in Table 5 all three dimensions of the linguistic and two of the dimensions of the visual code have a statistically significant relationship with the social impacts of Science and Technology as presented in Press, a fact that supports the initial theoretical proposition of this paper that these two codes are an important tool for 'framing' the S&T coverage. This statistically significant relationship by the inspection of the standardized residuals (Blalock, 1979), appears to exist mainly due to the S&T articles presenting negative impacts as shown in Table 6.

Table 6: The relationship between the three dimensions of the codes and the type of the social impacts of Science and Technology in the Greek Press

Dimension of the linguistic code	*Positive impacts*		*Negative impacts*	
	Linguistic	*Visual*	*Linguistic*	*Visual*
Low Emotional Involvement	●			
High Emotional Involvement			●	
Little Techno–Scientific Content and Explanation			●	
Much Techno–Scientific Content and Explanation	●			●
Low Formality				
High Formality			●	●

The results included in Table 6 can be summarized as follows:

- Press presents the negative social impacts of Science and Technology using highly charged emotional language, presenting low techno–scientific content and explanation by the linguistic code but much by the visual code respectively and also employing codes characterised by high level of formality and abstraction.
- The positive impacts are presented using not–emotional language and also by the provision of high levels of scientific content and explanation mainly by the linguistic code.

4. DISCUSSION

The finding of the generally positive image of Science and Technology projected by the Greek Press is in absolute agreement with both the image found in other similar studies (e.g. Eisniedel, 1992, Nelkin, 1995, etc) and the corresponding public opinion surveys' findings (e.g. Eurobarometers for Europe, Science and Technology Indicators for USA, etc). According to Nelkin, (1995) the changing perception of Press as far as the social impacts of Science and Technology follows a cyclic trend. While in the 1960s was a period of scientific and technological 'breakthroughs' and 'revolutions', this frame changed in the late 1960s and the 1970s when wonder gave way to concerns about environmental and social risks. hSince the 1980s though *'the enthousiasm of the 1960s has been born again though somewhat tempered by the continued fear of risk'*.

The current then positive image of Science and Technology in Press might reflect a generally positive climate of social acceptance of these two areas which in turn makes Press material a suitable educational means of forming positive attitudes to the students.

This positive image though is usually restricted by the rising occurrences of Press references to the negative impacts of Science and Technology thus creating a more realistic image than the unconditioned positive image that these two areas have in the school science textbooks.

The Greek Press seems to employ a range of linguistic and visual resources in order to present mainly the negative impacts of Science and Technology. Different aspects of the linguistic and visual code contribute to making up meanings for the reader and attract in this way his/her interest. More specifically Press seems to promote the involvement and the direct participation of the reader to the negative news, which are often related to risky and threatening situations. This involvement of the reader to the negative news is a prerequisite for enhancing the news–value of these articles and hence for attracting the readers' interest in reading them. The involvement of the reader is achieved at the emotional level by the use of particularly emotionally charged language whereas at the cognitive level by the provision of sufficient techno–scientific explanation through the visual code so as to allow him/her to build cognitive schemas in order to make sense of the situation presented. The visual code is considered more appropriate for providing lay readers with techno–scientific explanations since according to Messaris, (1998) its two basic properties are: the analogical relationship between images and the concepts for which they stand and the implicitness of the connections established through visual syntax. Both these properties seem more suitable for enhancing techno–scientific understanding to a lay reader since the analogical way of thinking is a natural way of understanding unfamiliar things (Lakoff and Johnson, 1980) and also according to Myers, (1991) *'the readers of scientific articles must have a knowledge of lexical relations to see the implicit cohesion, while readers of popularisations must see the cohesive relations to infer lexical relations'*. These cohesive relations are better presented by the visual code which according to Messaris, (1994) helps the readers to recognise them unthinkingly and automatically.

In the last two decades a number of technological accidents and risks (e.g. Chernobyl disaster, Global warming and Ozone Depletion Layers) have laid the ground for intense social criticism of Science and Technology and have attracted the public interest for more information. As a result of this tendency such issues have already entered the Science Syllabuses in many countries. The analysis above shows that Press material can be used in the teaching of such issues in order both to mobilise the students at an emotional level and also to provide the teachers with graphical illustrations of the underlying processes of good explanatory power.

The feeling of involvement promoted by the linguistic resources of the emotional expressions and the techno–scientific explanations by the visual code respectively increases the perceived victimization risk of individuals as it has been showed by the relevant research (e.g. Berger, 1998). The same perceived risk is also enhanced by the lack of techno–scientific background information by the linguistic code since according to Hornig, 1990 *'Contrary to expectations, respondents see scientific and technological* *developments higher in risk and with outcomes less under their control when they read stories that emphasize the social and political over the scientific and technical aspects of these developments'.*

Apart though from the feeling of involvement another factor that intensifies the risk perception of the reader is the trustworthiness of the news–item. The formal linguistic and visual style employed by the Press to present the negative social impacts of Science and Technology is associated with the codes of the elite which many studies have shown that are perceived as more credible especially in cases of risk communication (e.g. Wartenberg and Greenberg, 1992, Frewer, Howard, Hedderley and Shepherd, 1999).

To summarise the results of this study Press employs linguistic and visual codes mainly in order to present the negative impacts of Science and Technology. In order to speak in Aristotelian terms Press tries to become persuasive when presenting these negative effects by appealing to all three means of rhetorics: i.e. to pathos (emotional involvement), to logos (techno–scientific content and explanation) and to ethos (formality). In some cases it chooses for this the linguistic channel (emotional involvement) in others it chooses the visual channel (techno–scientific explanation) and in others it chooses both (formality) according to its perceived effectiveness of each mode of communication.

The further application of the linguistic and visual resources in the study of the non–specialist material about Science and Technology might be proved a very fruitful approach in the area of Science Communication and Science Education in particular since it allows the analysis of the textual and contextual features of the corresponding texts, revealing in this way the cognitive, social factors, conditions, constraints, or consequences and indirectly their socio–cultural embedding.

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The Pyramid Model–An Array of Programs in Science Education For All

Netta Maoz, Weizmann Institute of Science, Israel,
netta.maoz@weizmann.ac.il

BACKGROUND

More than a century ago, a group of educators met to discuss science preparation needed for college admission. This led to what can be called "some science for some students" (Hoffman, 1993). Since then the body of knowledge has exploded and the dependence of society upon scientific and technological advances expanded significantly. This led to the perception that science should not be taught only to those who will continue their education in the universities and colleges, but to all individuals.

Twenty–five years ago the notion "Science for All" started to spread around the world of science educators. It was understood that all future citizens should be exposed to some level of science and technology education in order to understand science to the extent that will allow him/her to critically judge everyday issues with scientific implications (Dori and Hofstein, 2000; Project 2061, 1994, Hoffman, 1993; Rutherford and Ahlgren, 1989).

This notion lead to the understanding that "the commitment to Science for All implies inclusion not only of those who traditionally have received encouragement and opportunity to pursue science, but of women and girls, all racial and ethnic groups ...... Further it implies attention to various styles of learning and different sources of motivation." (Hoffman, 1993). Many science educators discussed what should the content of science studies be from the viewpoint of future citizens, and many contributions to this issue were made throughout the world (Fensham, 1985, project 2061).

All these developments aimed at science studies in the formal educating system. But there is another source for educating students– the informal framework– often managed by the universities, research institutes and science museums. This framework is used very rarely in the education system and thus is considered as neglected resources for science education. (Maoz, 1993).

NEGLECTED RESOURCES – THE PROFESSIONALS

In universities, research institutes and science museums children meet with actual scientists, who convey their own point of view on the scientific process issues. (Subhi and Maoz, 2000)

Since the total of scientific knowledge is enormous we would like children to understand the scientific process in order to be able to critically judge and make decisions on subjects related to their life. A direct interaction with scientists contributes to the development of this understanding.

THE ISRAELI EXPERIENCE

The Weizmann Institute of Science, a science research institute, has pioneered in developing informal education programs for children and youngsters in Israel. The other Israeli universities adopted many of its programs and now Israel offers a network of informal science programs taking place in universities and research institutes (Eylon et al, 1985).

The Pyramid Model

It is accepted these days, that all future citizens should be exposed to a certain level of science and technology education, but it is also clear that it is impossible to present uniform programs to all. People have different fields of interest, different level of understanding and different learning styles (Hoffman, 1993).

Therefore the Youth Activities Section of the Weizmann Institute of Science offers the *pyramid model* as a framework for informal science education. It has been developing and implementing science programs for all levels of interest and ability for over 35 years. These enrichment programs are given either to school classes that come to the Weizmann Institute together with their teachers within the school framework, or to individuals who are willing to devote their time to learn science. The array of programs is structured as a pyramid. At its base there are programs that provide an experience in science to all; the middle level programs are aimed at students who want to know more than they learn at school; and at the top there are high level programs on a for gifted and talented youngsters.

The teaching staff in all programs is unique in that it consists of the scientists and research students of the Weizmann Institute.

WHY UNIVERSITIES?

There are three reasons why to conduct informal programs at the universities (Maoz, 1993).

a) Personnel

b) Flexibility and diversity of the curriculum

c) Sophisticated equipment

a. Personnel: University and Research Scientists as Educators

The personnel that interact with the youngsters is the most important and unique factor in these educational programs: The staff members and research students are all active scientists, who are able to convey, first hand, the essence of the scientific process to the students. They stimulate in learners the feeling of curiosity and excitement. Moreover, for many students the program provides a unique opportunity to meet actual scientists, thus appreciating that scientists are regular human beings, and apparently almost every curious individual may become a scientist. Even without becoming a scientist such appreciation may help bridging the gap between the scientific community and the significant non–science oriented section of society.

These scientists supplement the formal education system: active scientists are unable to teach in the regular school system, but by being involved in extracurricular education they contribute their special qualities to those who can profit from this experience. Another by–product might be an awareness of the scientists of the need to bridge the knowledge gaps in society.

b. Flexibility and Diversity of the Curriculum

The personnel involved in teaching the various programs changes as research students who acquire their degrees and leave are replaced by new students. Since they offer programs from their field of interest, the courses offered to the pupils change frequently, thus enable the children to choose whatever they want to study. The "teachers" are those that create the new knowledge and development, so there is no need to train them to teach their subjects.

These programs are additional to the school curriculum. An example of one interesting and intriguing subject, that has implications on our future life, is the Human Genome Project. It is impossible to run human genome experiments at school. Classes who come to the Institute with their teachers are able to experience the procedures associated with this subject and after experiencing hands–on experiments they discuss its ethical and social aspects.

c. Sophisticated Equipment

Universities, museums and research institutions possess unique equipment and instruments for conducting research. Children who enroll in the extracurricular programs have the opportunity to use equipment that will never be available in schools. Thus they realize that the scientific methods involve certain logic and quantitative measurements. Going through this process might help them to confront the mystical approach, which is becoming wide spread these days.

One good example is the above mentioned example given on the human genome.

SCIENCE YOUTH ACTIVITIES AT THE WEIZMANN INSTITUTE OF SCIENCE

The mission of the Youth Activities Section is to increase science literacy among school children and general population with the involvement and contribution of the scientists and research students of the Institute.

The philosophy is:

- To offer children and youngsters programs at various levels according to their abilities and needs.
- To let everyone choose whatever he wants and needs by a "self–selection" process.

The Implementation of the Pyramid Model

The science programs offered at the Weizmann Institute are of two kinds: programs for classes who come with their schoolteachers and programs for those who come on an individual basis.

The teachers who come with their classes are those who make the decision of a certain program out of a list of available ones. Those who come on an individual basis use the "self–selection" process. They are not labeled as gifted or talented students, and they decide for themselves if they can participate in a program, which requires a high level of understanding and commitment.

The pyramid consists of three levels:

- Programs for the general population
- Programs For students who want to know more
- Programs for the gifted and talented

THE BASE OF THE PYRAMID–SCIENCE POPULARIZATION

Garden of Science

The Clore Garden of Science is an open–air science museum, a museum without walls where even "the sky is not the limit". It exploits solar, wind and water energies to demonstrate physics phenomena. It contains giant exhibits to attract children and adults to experience and understand scientific laws relevant to everyday life.

The Garden is opened to all kinds of population: families, groups and school classes.

For example there are exhibits demonstrating a full circle rainbow; solar energy transformation into electric energy, which operates a fountain and an electric motor, which rotates a disc. Other exhibits demonstrate solar energy transformation into heat, which sets wood on fire and another exhibit demonstrates a solar water heater, which is in a common use in Israel. Yet another series of exhibits deals with: water, sound and light waves, and many others. This is a hands–on science center, where the visitors experience the operation of the exhibits and are stimulated to "minds-on" understanding.

The Garden offers science activities to K–8th school classes in sensing senses, stability, waves, solar energy and circular motion.

Popular Science Lectures

Every year a series of popular lectures on current scientific issues are given by eminent scientists of the Weizmann Institute. The scientists share their work with the public, thus making the public acquainted with the frontiers of science and demonstrating the scientific process. Most of the audience is high school students and their teachers.

Science Mobile

A van equipped with scientific equipment and demonstrations travels to settlements around the country. Instructors present science experiments and teach subjects chosen by the teachers from a list of offered programs. Thus many children who live far away from the Institute and do not have the possibility to come there, have the opportunity to experience demonstrations and hands–on activities. There is a hope that these programs arouse curiosity and will cause these children to participate in more science programs in the future.

"Morning of Science"– Science Field Days for Junior High School

Classes of students, 5th–9th grades, accompanied by their teachers, come to the Institute for a four hours program, selected from a variety of activities, in physics, chemistry, biology and interdisciplinary subjects. The content of the programs differs from the material learned at school – it is either an addition to school science or a topic not taught as part of the curriculum.

The programs consist of lectures, demonstrations and hands–on activities. The students can also experience relevant exhibits at the Garden of Science and some Institute facilities, such as the Solar Tower, an installation that studies how to harness solar energy for the benefit of mankind.

THE CENTER OF THE PYRAMID–PROGRAMS FOR STUDENTS WHO WISH TO KNOW MORE SCIENCE

"Journeys in Science"–Field Days for High School

In the Israeli education framework high school students in 11th–12th grades have to choose a major subject to learn on a high level. Some choose to major in the sciences (math and physics, biology and chemistry, etc).

"Journeys in Science" is a program aimed at high school students who major in one of the sciences. The programs present to the students the world of science: "open" questions in science and how they are approached, advanced research procedures and scientific methods. They also deal with socio–ethical issues. The programs differ in length from 6 hours to two days. Many of them include visits to the relevant Weizmann Institute research laboratories.

Science Clubs

This program is aimed at children at 2nd–12th grades who want to know more than they can get at school. They come on an individual basis in the afternoons during the academic year. They choose what to learn from a long list of offered courses, taught by research students and staff members, who teach in their field of expertise. The subjects are taken from the fields investigated at the Weizmann Institute, and are given primarily by the research students.

PROGRAMS FOR GIFTED AND ABLE CHILDREN

Some programs are offered to interested, top students:

- Math–by–Mail
- "Arrow"–Young Researchers
- Residential Summer Programs
- Competitions and Olympiads

Math–by Mail

This program is offered to math enthusiasts in grades 3rd–10th, all over the country. Mathematicians and mathematic educators prepare sets of problems in 4 grade levels. The problems emphasize the development of mathematical thinking. The enrolled students receive worksheets addressing subject matter and new approaches that differ from those studied at school. For example, problems can deal with graph theory, number theory, statistics, game theory or operators.

Written answers are corrected, graded, and returned to the students with a printed solution and the next worksheet. At the end of the year the students are invited to come to the Weizmann Institute to participate in a hands–on math experience.

Experience indicates that all over the country, teachers use these worksheets for enhanced lessons offered to excellent students who learn in heterogeneous classes

This program is translated into the Russian language and takes place in former Soviet Union countries. It may also be translated into English and Korean for the benefit of South Korean children.

"Arrow" – Young Researchers

High school students who are very interested in doing research, can work in the Institute's laboratories on special projects. Scientists mentor these students. In order to be accepted to this program they should be talented, very motivated and ready to sacrifice their free time.

Residential Summer Programs

The Weizmann Institute operates three residential summer programs:

INTERNATIONAL SUMMER SCIENCE INSTITUTE

The International Summer Science Institute is dedicated to bringing together some 75 talented pre–university science students from all over the world in order to experience the challenges and rewards of scientific research, as well as to learn more about the Weizmann Institute and life in modern Israel.

Divided into small groups of twos and threes, participants work on actual on–going research projects of their choice under the supervision of Weizmann graduate students and scientists. This intensive program offers the opportunity to taste the realities of research through hands–on experience. The projects are both demanding and rewarding, allowing participants to explore, discover and have fun in the process.

Upon completion of laboratory work, a participant makes an oral presentation before an assembly of peers and mentors and submits a written report.

The program also includes supplemental lectures, departmental talks and visits to some of the state–of–the–art facilities on campus.

After spending three weeks at the Institute, the group shifts to an altogether different scientific focal point– a field school in the Judean Desert, near the Dead Sea. The expert guides from the school lead hikes that acquaint participants with the ecological, geographical, geological, zoological and archeological characteristics of the area.

National Science Workshop

This intensive two–week summer program is aimed for outstanding Israeli science–oriented high–school students. The students stay on campus and work on research projects supervised by Institute scientists in their laboratories.

Participants give a brief oral presentation and submit a written report on their projects. In addition, lectures and social activities are scheduled during free time. Each year, several outstanding participants are selected as recipients of university scholarships.

Science, Music and Art Program

This is a special two–week program for sixty 14–year old students who show potential to excel either in science, music, or art. The purpose of this program is to broaden the scope of youngsters by establishing connections among the disciplines (Maoz, 1990, Subhi and Maoz, 2000).

In the mornings the participants study in groups based on their interests; in the afternoons they participate in interdisciplinary workshops, working with youngsters drawn from the three domains; evenings are devoted to either lectures by top scientists raising special issues in science, or meeting with professionals actors, artists and musicians.

Competition and Olympiads

The Weizmann Institute runs two Math Olympiads for high school and for junior high school students.

Another science competition is the Physics Tournament:

The physics tournament is a competition among five–person teams from various high schools around the country. The students are requested to plan and build a safe locking device based on scientific principles.

The safes are brought for a two–day happening at the Institute and the teams compete on understanding the mechanisms built by the other teams, by trying to "break" into them.

The most exciting aspect of the tournament is the time, devotion and talent of the team members for several months before the tournament. Going through the process of planning and building the mechanism, the participants are exposed to the entire process of inventing an apparatus based on a scientific concept. They have to select the right idea, ascertain feasibility of its implementation, find the optimal parameters and guarantee its robustness.

There is no doubt that the students acquire a lot of scientific content and concepts, much more than is gained by the formal framework.

Some teachers use this competition to better science educations at their schools.

AN ACTIVE INTERNET SITE

In the summer of 2001 an active internet site will be launched on the web. In the site there will be a variety of possibilities: some will be based on surfing, such as popular science lectures, science news, etc. The main activities will be based on active participation of the surfers, such as problem solving activities, competitions, special science clubs that will take advantage of having a wide range of participants, math–by–e–mail problems, etc.

This will make Weizmann programs available for Israeli kid from all over the country. Eventually many programs will be in English, to enable children from anywhere in the world participate.

SUMMARY

The pyramid model provides a variety of science programs to all kinds of students: starting from programs for a general population to programs for those who want to get in depth into the scientific experience.

It also caters to different learning styles: children can choose between individual learning, learning with his/her class, learning in a club with children that he/she do not meet in the near neighborhood or participate in teamwork. All these styles advance understanding of science.

The overall annual number of participants is ~22,000. About 89% participate in the programs for classes and ~11% in the programs available on an individual basis.

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Balancing Between Algorithmic and Nonalgorithmic Methods in Solving Chemical Problems

Zoltán Tóth, University of Debrecen, Hungary, *o319tz@tigris.klte.hu*

It is very important to find the correct ratio i.e. balance between the algorithmic and non–algorithmic problem solving methods from the point of view of improving students' thinking methods and developing effective problem solving skills. Chemical calculations give ample opportunities to influence students' way of thinking, to investigate their problem solving strategies and misconceptions, as well as to develop logical methods into algorithms, to check appropriate use of algorithmic thinking, and to illustrate the diversity and variety of problem solving thinking.

Students usually apply the following strategies in problem solving: trial and error method, logical induction, and algorithms. The simplest problem solving strategy is the trial and error method. Students can apply this strategy with reasonable success to solve plain problems with two or maximum three variables presuming we get integer numbers as a result of the numerical calculation. Logical methods mean all problem solving strategies which are based on inductive thinking, the students haven't met the problem yet and which are the consequence of some special features of the problem. Algorithms mean deductive problem solving methods which can be applied to a quite wide group of problems. It is basically true that one or more solving algorithms can be constructed for all chemical calculation problems (Tóth, 2000).

One of the most important and oldest question in school teaching: can we and should we teach problem solving methods and algorithms? Or instead of that, on the basis of premises of teaching logical thinking we must try to help students to find the solution of the given problem logically, by themselves. According to the literature (Zoller, 1995) the algorithmic problem solving is considered as practice and as such a lower order cognitive skill while logical solutions are considered as problem solving and a higher order cognitive skill. While the first method i.e. algorithms can make solution of certain problems in fast, error free and routine process, the logical way of thinking is uncertain, and considerable amount of time and effort is needed to find the good solution. However, algorithms in certain extent eliminate thinking, and solution of the problem becomes a mechanical process, while logical thinking demand for an active cognitive process, and help to develop students' problem solving skills and thinking. Basically all students can be taught to use algorithms but only students with appropriate knowledge base and skills can be taught for logical thinking. As a consequence, for certain chemical calculation problems we can not neglect use of algorithms as for example it is expected from all students to know how to balance chemical equation, calculate concentration or perform simple stoichiometric calculations.

However, the proper way of teaching algorithms does not mean that teacher should give a ready algorithm for the students, and even state the main points step by step how to solve the problem. On the contrary, based on students' previous knowledge base teacher must choose from different types of problems to help students to discover the solving algorithm by themselves. From the point of view improving the thinking methods it is advisable to check the correct and appropriate use of algorithms which can be achieved when students are asked to explain the solution method of the problem or the problem itself can be changed in such a way that it can't be solved by mechanical use of the known algorithm. It is also important to make students realise that for various problems different solving algorithms can lead to the simplest solution i.e. changes of algorithms should be performed frequently (Tóth, 2000).

A few chemical calculation problems are presented to induce students' logical thinking, to develop the logical ways of thinking into algorithms, and to provoke changes in the algorithm

Balancing chemical equations

Some selected problems help to develop a good practice and algorithm for balancing reaction equations i.e. the chain rule (Tóth, 1997; 2001a). One can see students' trial and error techniques and misconceptions related to this method. Than transformation of the trial and error method into a simple logical method and finally development of algorithmic methods i.e. chain rule and method of coupled equations from the simple logical method can be traced. Choosing carefully selected problems we can reach the need for the change of an established algorithm i.e. to transfer the chain rule into solving methods based on the concept of oxidation numbers.

The following problems help to develop a good practice and algorithm for balancing reaction equations i.e. the chain rule. We start with a few simple equation to verify that students fully understand the concept of stoichiometric coefficients and meaning of indices in the formulas.

$2Ca + O_2 = 2CaO$

$4Fe + 3O_2 = 2Fe_2O_3$

$Zn + 2HCl = ZnCl_2 + H_2$

Than come more difficult reaction equations which can be balanced starting with any of the element. In parenthesis we give possible sequences for the elements to the balancing, too.

$2Mg + CO2 = 2MgO + C$ (Mg,O,C or O,C,Mg or O,Mg,C or C,O,Mg)
$Fe2O3 + 3C = 2Fe + 3CO$ (Fe,O,C or C,O,Fe or O,C,Fe or O,Fe,C)
$4NH3 + 3O2 = 6H2O + 2N2$ (N,H,O or H,N,O or H,O,N or O,H,N)

In this problems we must explain students that in these cases balancing can be started with any of the element but it can only be continued with element which is present in only one compound with unknown coefficient. It is advisable to ask to write the coefficient 1, too! However, in these cases a misconception can occur i.e. students balance the equation only for two independent element (Mg,C; or Fe,C; or N,O) and do not recognise, that the equation is not balanced for the third element. In this way we can get the following wrong solutions: $Mg + CO_2$ (=) $MgO + C$; $Fe_2O_3 + C$ (=) $2Fe + CO$; $2NH_3 + O_2$ (=) $2H_2O + N_2$. In such a case we can show how to couple two balanced equations via a third, common atom or element.

The next equations can be balanced if we start with two elements

$CS_2 + 3O_2 = CO_2 + 2SO_2$ (C,S,O or S,C,O)
$4NH_3 + 5O_2 = 6H_2O + 4NO$ (N,H,O or H,N,O)
$4FeS_2 + 11O_2 = 2Fe_2O_3 + 8SO_2$ (Fe,S,O or S,Fe,O)

In these examples we'd warn students that we can not start the balancing with oxygen as it can be found in more than two compounds.

Now only one element is good to start the balancing with

$C_6H12O_6 = 2C_2H_6O + 2CO_2$ (H,C or H,O)
$CH_4 + 3Cl_2 = CHCl_3 + 3HCl$ (C,H,Cl)
$5HI + HIO_3 = 3I_2 + 3H_2O$ (O,H,I)
$3N_2H_4 + 4HNO_2 = 5N_2 + 8H_2O$ (O,H,N)

After these exercises we should emphasise and make student realise that balancing can be started only with such an element which is constituent of not more than two compounds. It is especially important to pinpoint the following wrong way of thinking for example in equation of reacting methane with chlorine: 'There are altogether 4 chlorine atoms at the right side of the equation so we should take two chlorine molecules at the left side...' However, in some cases this wrong balancing strategy can result the correct answer, for example in equation of glucose oxidation ' there are 3 carbon atoms at the right side so a coefficient of 2 should be written for both molecules and in this way there will be 6 carbon atoms at the right side, too'.

Finally we can practice and check the correct application of the chain rule by balancing complicated equations

$4HCl + MnO_2 = MnCl_2 + 2H_2O + Cl_2$ (H,O,Mn,Cl or Mn,O,H,Cl)
$2KMnO_4 + 16HCl = 2KCl + 2MnCl_2 + 5Cl_2 + 8H_2O$ (K,Mn,O,H,Cl etc.)
$2Al + 2NaOH + 6H_2O = 2Na[Al(OH)_4] + 3H_2$ (Na,Al,O,H)
$5KBr + KBrO_3 + 6HCl = 3Br_2 + 6KCl + 3H_2O$ (O,H,Cl,K,Br etc.)
$4S + 6NaOH = 2Na_2S + Na_2S_2O_3 + 3H_2O$ (H,O,Na,S)
$12KI + 5C_2H_5OH + 13H_2O = 6K_2CO_3 + 26H_2 + 4CHI_3$ (K,I,C,O,H or I,K,C,O,H)

However, if we want to step forward and not only the chain rule is taught as an equation balancing algorithm but we want to introduce new balancing methods based on the concept of oxidation numbers – which is a change of algorithm –, too, we should give equations to be balanced where application of the chain rule is possible only with introduction of an unknown parameter and where the mentioned wrong strategies would give wrong results. (For this reasons it is not advisable to balance chemical equations such as $Cu + 2H_2SO_4 = CuSO_4 + SO_2 + 2H_2O$; $I_2 + 2Na_2S_2O_3 = 2KI + K_2S_4O_6$).

$HN_3 + 5NH_3 = 4N_2H_4$

$3Cu + 8HNO_3 = 3Cu(NO_3)_2 + 2NO + 4H_2O$

$FeS_2 + 8HNO_3 = Fe(NO_3)_3 + 2H_2SO_4 + 5NO + 2H_2O$

If we want students recognise that depending on the complexity of the problem these two algorithms are used alternatively, problems should be presented which are difficult and cumbersome to balance with oxidation numbers but they are easy to balance with the chain rule.

$CaC_2 + 3CO = 4C + CaCO_3$

$2NaClO_2 + Cl_2 = 2NaCl + 2ClO_2$

$2NH_2Cl + N_2H_4 = 2NH_4Cl + N_2$

$13P_4 + 10P_2I_4 + 128H_2O = 40PH_4I + 32H_3PO_4$

Stoichiometric problems

Stoichiometric calculations give a unique opportunity to transform the simple logical thinking into an algorithm as well as to change the algorithm i.e. calculation on the basis of triple rule instead of mole concept (Schmidt, 1994). The following stiochiometry calculation problems can offer a unique opportunity to develop the logical method into an algorithm:

First let's start with problems which can be solved easily with simple logic.

"How many grams of sulfur, copper, magnesium or tellurium can be found in 6 g of SO_2 CuS_2, MgC_2 *or* Cu_2Te, *respectively? (Relative atomic masses:* $O = 16$, $S = 32$, $Cu = 64$, $Mg = 24$, $C = 12$, $Te = 128$.*)"*

The essence of the simple logical answer is to recognise that in these compounds the constituents are in a one to one mass ratio so the correct answer which can be calculated easily is that 3 g. According to a survey (Schmidt, 1994) among German secondary school students 50–60% of them used this simple logical method while 5–15% applied the concept of mole and 15–20% of the used the so called triple rule. (However it can be noted that this problem can be solved by using the so called dimension analysis which is unfamiliar and not widely used in teaching chemistry in Europe.) The simple logical method is advisable to show even when students do not use it.

Then we can give more complicated problems which are difficult to solve using the simple logical method and they are easier to solve by using the concept of mole or triple rule.

"How many grams of lithium, gallium, molybdenum or titanium is in 60 g of Li_3N,

$GaCl_3$, Mo_2S_3 or TiO_2, respectively? (Relative atomic masses: Mo = 96, S = 32, Ga = 70, Cl = 35, Li = 7, N = 14, Ti = 48, O = 16.)"

Of course a logical method exists in these cases too, but it is not so simple as in the previous problems. For example in case of Li3N one can say, that 'molar mass of nitrogen is double of that of lithium and as at the same time their molar ratio is 1:3 their mass ratio is 2:3 so 3/5 part of the mass of the compound is lithium i.e. there is 36 g lithium in it.' At this point students using the simple logical method can realise that the solution is much more simple and error free by using the concept of mole or the triple rule.

In the next step we can give problems which are very difficult to solve using the simple logical thinking method.

"How many grams of sodium is in 79 g of $Na_2S_2O_3$? (Relative atomic masses: Na = 23, O = 16, S = 32.)"

The following problems related to the combustion of hydrocarbons help to change the concept of mole to the triple rule:

"During the combustion of 100 cm3 saturated, open–chain hydrocarbon gas of unknown molecular formula in normal state 241 mg water is formed. Which hydrocarbon was burned?"

This problem can be solved easily both by using the concept of mole or by the triple rule. The mole concept: We have $4.46.10^{-3}$ mol hydrocarbon and $1.34.10^{-2}$ mol water. 1 mol hydrocarbon gives (n+1) mol water. Thus: n = 2. The triple rule: 22410 cm^3 hydrocarbon gives 18(n+1) g water, while 100 cm^3 hydrocarbon gives 0.241 g water. Therefore n = 2.

"After the combustion of 1.000 g saturated, open–chain hydrocarbon the total mass of the products is 4.535 g. Which hydrocarbon was burned?"

In case of this problem the mole–concept is not so simple as in the previous problem. The easiest solving method of this problem is the triple rule: Based on the reaction equation (14n+2) g hydrocarbon gives (62n+18) g reaction products, while 1.000 g hydrocarbon gives 4.535 g products, and solving gives n = 6.

Solubility problems

Development of simple logical thinking into algorithm can be reached by carefully chosen problems as well as algorithmic and non–algorithmic methods can be varied depending on the problem (Tóth, 2000). The following examples show the steps of changing simple logical methods to algorithms:

LOOKING FOR A LOGICAL METHOD

"How many g of KNO_3 remains by evaporating 400 g of saturated solution at 20°C. 100 g water dissolves 31.6 g KNO_3 at 20°C."

Students realize the mass conservation law both for the solute and the solvent. Logical method: Since 100 g water dissolves 31.6 g salt, 131.6 g solution contains 31.6 g salt.

Therefore 400 g solution contains 96.0 g solute. Thus, after the evaporation 96.0 g salt precipitates.

"How many g of $CuSO_4{\times}5H_2O$ *remains by evaporating 200 g of 10.0 w/w%* $CuSO_4$ *solution?*

The molar masses are 250 g/mol, and 160 g/mol for $CuSO_4{\times}5H_2O$*, and* $CuSO_4$*, resp."*

Students realize that all the $CuSO_4$–content, but only one part of the water–content of solution remains as hydrated solid. Logical method: 200 g solution contains 20.0 g $CuSO_4$, so the remaining hydrated solid also contains 20.0 g $CuSO_4$. If there is 160 g $CuSO_4$ in 250 g $CuSO_4{\times}5H_2O$, therefore there is 20.0 g $CuSO_4$ in 31.2 g $CuSO_4{\times}5H_2O$. Thus, we get 31.2 g hydrated salt by evaporating the solution.

"How many grams of KNO_3 *crystallizes if we cool a saturated* KNO_3 *solution from 80°C to 20°C, and 200 g of solution saturated at 20°C remains. 100 g water dissolves 31.6 g* KNO_3 *at 20°C, and 169 g at 80°C."*

Students realize that the amount of water in the solution doesn't change. Logical method: At 20°C 200 g solution contains 48,0 g KNO_3 and 152 g water. The initial solution also contained 152 g water. At 80°C 152 g water dissolves 257 g KNO_3. Thus, (257 g – 48,0 g) = 209 g KNO_3 crystallized when cooled the solution from 80°C to 20°C.

LOOKING FOR ANOTHER LOGICAL METHOD OR USING ALGORITHM

"How many grams of saturated KNO_3 *solution at 80°C should be prepared to get 50.0 g* KNO^3 *deposited when the solution is cooled to 20°C? 100 g water dissolves 31.6 g* KNO_3 *at 20°C, and 169 g at 80°C."*

Students realize that they can't calculate the amount of water in any solution, therefore they have to look for another logical method or one of the algorithms. Another logical method: By cooling a solution saturated at 80oC containing 100 g water, we get (169 g – 31.6 g) = 137 g salt. To get 50.0 g salt deposited one have to prepare a solution saturated at 80oC containing 36.5 g water. 36.5 g water dissolves 61.7 g salt at 80oC. Thus, the mass of the initial solution is: (36.5 g + 61.7 g) = 98.2 g.

ALGORITHMS: LET X STAND FOR THE MASS OF THE SOLUTION SATURATED AT 80OC.

Algorithm 1 (the mixing rule): $m_1{\times}c_1 = m_2{\times}c_2 + m_3{\times}c_3$ where m_1 = x g (the mass of the saturated solution at 80°C), c_1 = 62.8 m/m% (the composition of the saturated solution at 80°C), m_2 = 50.0 g (the mass of the salt precipitated), c_2 = 100 m/m% (the composition of the pure KNO_3), $m_3 = (m_1 - m_2)$ = (x – 50.0) g (the mass of the remaining solution at 20°C) and c_3 = 24.0 m/m% (the composition of the saturated solution at 20°C).

Algorithm 2 (the balance method):

	Sat. solution at 80°C		KNO_3+		Sat. solution at 20°C
Mass /g:	x	=	50.0	+	(x–50.0)
Mass fraction:	169÷269		1		31.6÷131.6
Mass of KNO_3 /g:	169×x÷269	=	50.0	+	(x–50.0)×31.6÷131.6

Algorithm 3 (the mass enlarging method):

	Mass of solution /g	Mass of KNO_3 /g
Saturated solution at 80°C:	x	169×x÷269
Change in mass during precipitation of KNO_3:	– 50.0	– 50.0
Remaining solution at 20°C:	(x–50.0)	(169×x÷269 – 50.0)

At 20°C: $m(KNO_3) / m(sol.) = 31.6 / 131.6 = (169\times x\div 269 - 50.0) / (x - 50.0)$

"How many g of $CuSO_4\times 5H_2O$ crystallizes if we cool a saturated solution at 80°C to 20°C, and 200 g of solution saturated at 20°C remains? 100 g water dissolves 20.7 g $CuSO_4$ at 20°C, and 53.6 g $CuSO_4$ at 80°C. The molar masses are 250 g/mol, and 160 g/mol for $CuSO_4\times 5H_2O$, and $CuSO_4$, resp."

Likely, some of the students observe that this problem can be solved by using the logical method, if they consider $CuSO_4\times 5H_2O$ as a solute instead of $CuSO_4$, but most of them need the algorithm. Logical method: At 20°C 100 g water dissolves 20.7 g $CuSO_4$. 20.7 g $CuSO_4$ is the equivalent of 32.3 g $CuSO_4\times 5H_2O$. At 20°C 88.4 g water dissolves 32.3 g $CuSO_4\times 5H_2O$. At 80°C 100 g water dissolves 53.6 g $CuSO_4$. 53.6 g $CuSO_4$ is the equivalent of 83.8 g $CuSO_4\times 5H_2O$. At 80°C 69.8 g water dissolves 83.8 g $CuSO_4\times 5H_2O$. At 20°C 200 g solution contains 53.5 g $CuSO_4\times 5H_2O$ and 146.5 g "free" water. The initial solution also contained 146.5 g "free" water. At 80°C 146.5 g water dissolves 176 g $CuSO_4\times 5H_2O$. Thus, (176 g – 53.5 g) = 122 g $CuSO_4\times 5H_2O$ crystallized from the solution.

"How many grams of saturated $CuSO_4$ solution at 80°C should be prepared to get 50.0 g $CuSO_4\times 5H_2O$ deposited when the solution is cooled to 20°C? 100 g water dissolves 20.7 g $CuSO_4$ at 20°C, and 53.6 g $CuSO_4$ at 80°C. The molar masses are 250 g/mol, and 160 g/mol for $CuSO_4\times 5H_2O$, and $CuSO_4$, resp."

Students find the logical method to be very complicated, therefore they prefer the algorithm. Logical method: At 20°C 100 g water dissolves 20.7 g $CuSO_4$. 20.7 g $CuSO_4$ is the equivalent of 32.3 g $CuSO_4\times 5H_2O$. At 20°C 88.4 g water dissolves 32.3 g $CuSO_4\times 5H_2O$. At 20°C 100 g water dissolves 36.5 g $CuSO_4\times 5H^2O$. At 80°C 100 g water dissolves 53.6 g $CuSO_4$. 53.6 g $CuSO_4$ is the equivalent of 83.8 g $CuSO_4\times 5H_2O$. At 80°C 69.8 g water dissolves 83.8 g $CuSO_4\times 5H_2O$. At 80°C 100 g water dissolves 120 g $CuSO_4\times 5H_2O$. By cooling a solution saturated at 80°C containing 100 g "free" water, we get (120 g – 36.5 g) = 83.5 g $CuSO_4\times 5H_2O$. To get 50.0 g $CuSO_4\times 5H_2O$ deposited we have to prepare a solution saturated at 80°C containing 59.9 g "free" water. 59.9 g water dissolves 71.9 g $CuSO_4 \times 5H_2O$ at 80oC. Thus, the mass of the initial solution is: (59.9 g + 71.9 g) = 132 g.

ALGORITHMS ALWAYS WORK, BUT SOMETIMES LOGICAL METHODS ARE SIMPLER ALL THE SAME

After the algorithm has been improved it is necessary to give the students problems requiring the meaningful application of the algorithm instead of the mechanical usage, or having very simple logical method for solution.

"KNO_3 is recrystallized. What is the maximum percent of conversion, if we cool saturated solution at 80°C to 20°C. 100 g water dissolves 31.6 g KNO_3 at 20°C, and 169 g at 80°C."

Logical method: Let us cool saturated solution containing 169 g salt and 100 g water. Then (169 g – 31.6 g) = 137 g KNO_3 precipitates. This amount is 81.1% of the initial amount (169 g) of KNO_3.

"The saturated solution of $MnCl_2$ is 53.0 w/w% at 80°C, and 42.5 w/w% at 20°C. If a saturated solution at 80°C is cooled to 20°C 59.6 % of $MnCl_2$ crystallizes. How many moles of water does 1 mol salt crytallize with at 20°C?"

Logical method: Let us cool 100 g of solution saturated at 80°C. This solution contains 53.0 g $MnCl_2$ and 47.0 g water. 0.596×53.0 g = 31.6 g $MnCl_2$ crystallizes from the solution. The saturated solution contains (53.0 g – 31.6 g) = 21.4 g $MnCl_2$ at 20°C. The mass of the saturated solution at 20°C is 50.4 g. The mass of the hydrated $MnCl_2$ is (100 g – 50.4 g) = 49.6 g. The hydrated $MnCl_2$ contains 31.6 g $MnCl_2$ and 18.0 g water. The mole ratio of water to $MnCl_2$ is 1.00 : 0.250, that is 4:1. The $MnCl_2$ crystallizes with 4 mol water at 20°C.

Two component mixture problems

This group of problems can mean not only chemical problems. They give good chance to use and improve trial and error methods, simple logical thinking and use of various algorithms (Tóth, 1999; 2001b). In solution of different problems different strategies are the simplest and easiest solving methods. By variation of problems teacher can provoke the changes in the strategies. Some example are as follows.

"A sample of a mixture containing 12 moles of methane and ethylene was burned completely in excess amount of oxygen to yield 20 moles of carbon dioxide. How many moles of methane were there in the initial mixture?"

Probably, the easiest solving strategy for this problem is the following: Suppose that all 12 mols of the sample were pure ethylene. Than the amount of CO_2 would be 24 mol. We must decrease the amount of CO_2 by 4 mol to obtain 20 mol. When we put 1 mol CH_4 instead of 1 mol $C2H_4$, the amount of CO_2 decreases by 1 mol, therefore we must put 4 mol CH_4 instead of 4 mol $C2H_4$ to obtain 20 mol CO_2.

"A sample of a mixture containing methane and ethylene was burned completely in

excess amount of oxygen to yield 20 moles of carbon dioxide and 24 moles of water. How many moles of methane were there in the initial mixture?"

Probably, the easiest solving strategy for this problem is the following: Define: x = mol of methane, and y = mol of ethylene in the initial mixture. On the basis of balanced equations for burning of methane and ethylene one can write an equation for the amount of CO_2 (x + 2y = 20), and H2O (2x + 2y = 24), and solving gives x = 4 mol.

"A sample of a mixture containing methane and ethylene was burned completely in excess amount of oxygen to give a reaction product containing 40.0 n/n% of carbon dioxide and 48.0 n/n% of water. What was the composition (in n/n%) of the initial mixture?"

Probably, the simplest solving strategy for this problem is the following: If 1 mole of the mixture contains x mole of methane and (1–x) mole of ethylene the average molecular formula for the mixture can be written as $C_{2-x}H_4$. The n(H) : n(C) mole ratio can be given as 4 : (2–x) on the basis of average molecular formula, and 2×48 : 40 according to the composition of the reaction product. From the equation, 4 : (2–x) = 2×48 : 40, we get x = 0.333, that is the mixture contained 33.3 n/n% of CH_4.

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New Trends in Methodology Training for Teachers of Biology and Geology at the Charles University

Milada Švecová, Jaroslava Pavelková, Václav Ziegler, and Dobroslav Matějka,
Charles University Prague, *svec@natur.cuni.cz*

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ABSTRACT

The current progressive trend of all teaching methodologies is to make school training practice more effective in relation to changing needs of today's society.

The key intent as to organizational and content related changes in methodology training in biology and geology at the Charles University is to strengthen practical components of training and to emphasize the application of expertise in solving practical problems in agriculture, forestry and health care.

Strengthening practical components in education links to capacity building in undergraduate training of teachers: long-term and short-term projects, implementing energizing methods and forms of work, evaluating training results, reflecting results of biology and geology curricula research.

Education in nature science relates to environmental education as well as to defining the subject matter with respect to pupils' age particularities and suitable methodological interpretations.

INTRODUCTION

Methodology training in biology and geology forms part of teachers training at the Charles University (this concerns both the Faculty of Science and the Faculty of Education). Its organizational structure at the two faculties shares some features and differs in regard to others, reflecting specifics characterizing the two faculties from the point of view of teacher training. Such specifics involve time schedule of specialized methodology training, partially also its content, its extent and the manner of evaluation. Very close cooperation of the two faculties of Charles University that train biology teachers for secondary schools and in the case of the Faculty of Education also biology teachers for elementary schools may be regarded as a very important.

INTRODUCING METHODOLOGY TRAINING OF BIOLOGY AND GEOLOGY INTO THE CURRICULUM

Specialized methodology training is introduced during the same year of studies at both faculties (the third year), but in different terms - at the Faculty of Education in the course of the winter term and at the Faculty of Science in the course of the summer term. This one term difference is reflected in concluding the specialized methodology training. At the Faculty of Science, specialized methodological training is implemented continuously in the course of three following terms and it is concluded with an exam. Organizational forms of training during the first term include both lectures and seminars, but the following two training courses of specialized methodology include only seminars and site visits.

At the Faculty of Education of the Charles University, specialized methodology training is also designed for three terms, but the training is disrupted by one term between the third and fourth year of studies. Each term is, in accordance with the curriculum, concluded with an exam and a credit. As to organizational forms of training, lectures and seminars predominate. The Faculty of Education is also specific in including features of methodological training into courses (both lectures and seminars) which form part of the specialized training, i.e. falling among biology disciplines. Methodology training is only a follow-up, dealing in particular with the process of transforming the expertise into biology curricula and with developing methodological issues.

At both faculties, specialized methodology training opens with courses "Introduction to Methodology Training in Biology," which are rather similar in content. It follows the previous training in pedagogy and psychology taught during earlier terms. From the point of view of these preparatory courses which are followed by specialized methodology training, students of faculties of education, including the Faculty of Education of the Charles University are at an advantage.

THE CURRICULUM INCLUDES THE FOLLOWING COURSES:

General Methodology Training (previously School Pedagogy)

Elementary Pedagogic and Social Psychology

Elementary Social Pedagogy

Generally, it may be stated that training of future teachers in pedagogy and psychology more or less targets the needs of school practice.

On the other hand, teacher training at the Faculty of Science of the Charles University is more general from the point of view of preparatory courses preceding specialized methodology training.

THE CURRICULUM INCLUDES THE FOLLOWING COURSES:

Psychology for Teachers

Pedagogy for Teachers

Aside from pedagogical and psychological disciplines, the introduction of individual biology subjects (botany, zoology, anthropology, genetics, and so forth) is also significant for specialized methodology training which deals with the manner of transforming expertise in individual biology subjects into students' knowledge. The interconnection of biology as a science discipline with biology as a school subject taught at secondary or elementary schools is also very important (at elementary school level, the denomination "nature science" is used due to the inclusion of geography). *Key curricular innovations related to nature science subjects include the following*:

- Coordinating subject matters in curricular documents;
- Merging identical or similar themes of various subjects;
- Integrating subjects;
- Introducing umbrella subjects; and
- Designing final exams of integrated nature.

The course *Introduction to Specialized Methodology Training* focuses on defining the subject of methodology training in biology, curricular documents (educational programs, teaching plans, textbooks, teaching methods, work lists, methodological tests, methodological aid). Students are also acquainted with evaluating results as well as with the theory and practice of preparing tests related thereto. In connection with methods energizing pupils, emphasis is placed on including challenging methods - observations and experiment using non-traditional natural materials. The application of self-education methods aims at strengthening the intellectual skills of working with reference literature, atlases, training indexes and so forth.

The application of progressive trends in nature science disciplines as well as new trends in introducing organizational forms are also taken into account. Aside from traditional biology and nature science classes which for the most part emphasize the formal style of teaching, optionally introducing group or partner classroom work, in particular while working with natural materials, university students are, during lectures and related seminars, made aware of project teaching and the possibility of including methodological games.

In relation to EU requirements regarding nature science education, progressive trends are gradually analyzed to become increasingly more extensively applied in teaching nature science subjects, including biology and geology at elementary and secondary schools. These anticipate in particular the integration of subjects and introduction of wider areas (groups of subjects) superior to subjects of the curriculum. Current curricula include subjects, such as *Discovering Nature or Humans and Nature*.

ENVIRONMENTAL EDUCATION IN TRAINING TEACHERS OF BIOLOGY AND GEOLOGY

Education in nature science directly relates to environmental education, which is also included in the basic methodology training course.

The project "Sustainable Development - Creating Conditions" (UNESCO, 1998 - 2000) included carrying out a survey in Czech Republic's faculties that offer teacher training. Questioner finding revealed that in the case of faculties which train teachers of natural sciences and humanities, the methodology training component is for the most part underestimated. Only two faculties that offer teacher training pay attention to issues of choosing the subject matter and transforming it into elementary and secondary school courses.

On the basis of this survey, recommendations were proposed to the Ministry of Education, Youth and Sports of the Czech Republic and at the same time a team of university professors (the Forum of University Professors) was formed with the aim of practically implementing the findings of the project into curricula of faculties that train teachers of general education subjects in the Czech Republic.

Recommendations:

The array of current organizational forms of training has to be altered in curricula, strengthening practical training components - practical workshops, field work, site visits. The key intent is to strengthen self-education as well as active approach to mastering knowledge and skills. However, suitable studying conditions have to be established for this purpose by preparing a sufficient amount of learning materials.

INNOVATIONS TO STUDYING PLANS

The introduction of the credit system at the Faculty of Science of the Charles University divided specialized methodology training into three separate courses as of the school year 1999/2000:

- *Introduction to Methodology Training in Biology*
- *Observation and Experiment in School Practice*
- *Biology Site Visits at Schools*

In relation to the implementation of the credit system, practical components of training were strengthened also in specialized methodology training. The course "Observation and Experiment in School Practice" allows for more frequent incorporation of practical exercises using both traditional and non-traditional natural materials as well as examples of applied biology, for example bioindication, phytopathological aspects of dying forests, use of entomology, biological protection of plants, and so forth.

Another course of specialized methodology training "Biology Site Visits at Schools" include concrete model examples of methodologically designed site visits, using not only natural localities, but also various establishments such as botanical gardens or zoos. Teachers may use such visits quite effectively and easily, having incorporated them into the taught subject matter.

SUMMARY

The key intent as to organizational and content related changes in methodology training in biology and geology at the Faculty of Science of the Charles University is to strengthen practical components of training and to improve application of expertise in solving practical problems, for instance in agriculture, forestry and health care. Strengthening practical training component in undergraduate training of teachers directly relates to effective capacity building of future teachers: project teaching, incorporating new effective forms of work, knowledge related to the currently available textbooks and the critical evaluation thereof, choosing suitable natural materials for observations and experiment during practical workshops.

Course Name:

INTRODUCTION TO SPECIALIZED METHODOLOGY TRAINING – THEMATIC AREAS

Faculty of education of the charles university - third year, winter term, lecture (2 hours)/seminar (1), credit/exam faculty of Science of the Charles university - third year, summer term, lecture (1)/seminar (1), exam; fourth year, winter term, lecture (2)/seminar (2), credit/exam

Defining the subject of methodology training in biology, specialized methodology training

- Interdisciplinary character, links to pedagogy, psychology, disciplines of biology sciences.

Curricular Documents

- Educational programs;
- Training plans and curricula for teaching nature science at elementary and secondary schools, introducing nature science into educational programs of elementary and secondary schools, specifics of individual educational programs in relation to nature science;
- Nature science textbooks for elementary schools and high schools;
- Functions, structural features;
- Evaluation of textbooks' content using various criteria and specifics of individual textbooks series, structuring the subject matter; and
- Lists of textbooks approved by the Ministry of Education, Youth and Sports of the Czech Republic, approval clauses, textbook reviews.

Teaching Methods

- Summary and examples of their use in teaching biology with respect to some age particularities of pupils, the role of motivating pupils.

Teaching Methods Energizing Pupils

- Incorporation of challenging methods: observations and experiment, of self–education methods: working with popular and scientific reference literature, denomination indexes, working lists and workbooks.

Lesson Preparation

- Methodological guidelines in elaborating lesson preparation, examples of concrete preparation of an exemplar lesson for elementary and secondary schools;
- Specific objectives of teaching nature science and biology at various levels and types of schools and their relationship to general objectives; and
- Bloom's classification of objectives, setting forth the educational and training objective, Mager's method.

Creating Terminology and Biological Description

- Inductive and deductive manner of creating terminology, principles for creating it (superiority, coordination, subordination), terminological inconsistency of textbooks (examples); and
- Sketches (drawn terms), types of sketches, incorporation into taught subjects, sketchbooks used in nature science and biology.

Evaluation of Teaching Results and Marking

- Qualitative and quantitative assessment of pupils in relation to teaching nature science and biology, methodology training test;
- Varieties and types of tests; and
- Theory and practice of preparing tests, possibilities for preparing and interpreting test results and their application in evaluating teaching results in biology, international projects TIMSS and PISA.

Traditional and Modern Teaching Aids

- Wall posters (examples, criteria for selecting this type of aid), banners;
- Natural materials, herbariums, alcohol prepares, stuffed animals, use of multimedia applications; and
- VCR recordings (collections of VCR tapes), multimedia applications.

Challenging Task and their Incorporation into Nature Science and Biology

- Bases for preparing challenging tasks, their division and possibilities of incorporation, examples of challenging tasks from various fields of biology and their application.

**Specifics of Teaching Geographical Sciences*

- History and presence of teaching geographical sciences at elementary and secondary schools, differentiation from biological sciences, specific teaching aids, examples of motivating pupils.

**Environmental (Ecological) Education and Training*

- Defining terms: ecology, environment, nature protection, sustainable life;
- Environmental features in teaching nature science and biology and their incorporation into the subject matter;
- Environmentally friendly elementary schools, environmental school projects, centers of environmental education; and
- New trends in international environmental education, competitions in the field of environmental education.

Organizational Forms of Teaching Nature Sciences and Biology

- Exemplar lessons, laboratory work, biology seminar, practical exercises and site visits (characteristics, incorporation, examples); and
- Group training, methodology games, school projects.

Prevention in Teaching Biology

- Healthy life style, drug prevention.

Biology Competitions and Possibilities of Engagement in Creative Activities on behalf of Elementary and Secondary Schools Pupils

- "Olympics," expert activities of students.

Nature Science Training within the EU

- National and school curricula, new trends in teaching nature science subjects (integration, projects, creating broader areas of superior subjects, natural sciences and their training in EU countries).

* Themes are not included within specialized methodology training in biology at the Faculty of Education of the Charles University (later inclusion).

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Conforming Model of Teaching by Students' Learning Style Preparing Future Citizens

Mohammed Reza Behrangi, School of Education Teacher
Training University, Tehran–Iran, *Behrangi@saba.tmu.ac.ir*

Even though teaching methods has a long history, but its complement models of teaching has improved distinctively in the last decade. According to Wiles and Bondy If we compare the philosophies and learning theories in terms of the method of teaching we can see an emerging continuum which, on the one hand, is quite controlling and directing and on the other hand, is quite non–directive and student orienting (Wiles 2000).

Conforming Model of Teaching by Students' Learning Style (CMTSLS) is purposefully designed in order to meet the unique style of students learning and their conceptual systems. The CMTSLS has four dimensions i.e. social, cognitive, self–directed, and behavioral. Each dimension has elements that adjust them with the students' styles and levels of learning. Their style of learning could be verbal\linguistic, logical\mathematical, visual\spatial, musical\rhythmic, body\kinesthetic, interpersonal, and intrapersonal intelligence. Howard Gardner (1983), a cognitive psychologist at Harvard University, introduced these terms in his book "Frames of Mind: The Theory of Multiple Intelligence". By the levels of learning we mean knowledge, comprehension, application, analyses, syntheses, and, judgement. B. S. Bloom (1956), used these terms to emphasis hierarchical learning.

The students learn in different ways. They have different learning styles that correspond to the intelligence in which they are particularly strong. Some of the students learn best through;

- Listening, reading, writing, debating, spelling, orating, and memorizing.

Others through:

- Thinking deductively, dealing with numbers, recognizing abstract patterns. They like to be precise, enjoying counting, prefer orderly note taking. They like to solve math problems, and like to be organized. Still others like to:
- Think in, and visualize images and pictures. They like art, drawing, painting and sculpture. They easily read maps, chart and diagrams. They have good color sense, remember with pictures and create mental images. Some like to:
- Learn through rhyme, rhythm, and repetition. They are sensitive to pitch, rhyme, timbre, emotional power of music, writes to music, learns easily with music, sensitive to different sounds of nature while others like to:

- Learn through body movement, games and athletic easily, they learns best by moving, like to touch, act, and learn by participating in the learning process. Some learn easily:
- By groups, can develop relationships with others easily. They relate well, mixes well, have many friends, enjoy group activities, always ready to co–operate, easily understands social situations. And still others like to work alone. They are sensitive to their own values, deeply aware of their own feelings, deeply aware of their own strengths and their own weaknesses, and listen attentively.

The CMTSLS model in its four dimensions and their sub–set not only recognizes the use of "the Theory of Multiple Intelligence", the taxonomy of higher learning but more than that, it has the flexibility and capacity enough to adopt new rational educational ideas in preparing citizens for the prosperous society.

The four dimensions of the CMTSLS and its sub–sets are as bellow:

1– Social dimension– with regard to this dimension and the social models of teaching as its sub–sets a wide range of objectives can be achieved. The teacher emphasizes more on the interpersonal intelligence. The students participating, as partners investigating from dyads to groups and the whole class in order to acquire the skills necessary for living in a democratic society. They understand individual and social behavior and values through the study of interpersonal problems, building personal understanding, and the skills of integrative interaction, learning to think about social policy and how public policy often requires the balancing of several values that are difficult to uphold simultaneously. The teacher modulates teaching to ensure that all students' learning styles can grow. Synergy phenomenon in learning is the result of this dimension.

2– The cognitive dimension– with regard to this dimension and information processing models of teaching, as its sub–sets, a wide range of objectives can be achieved. The teacher emphasizes more on the interpersonal, verbal\linguistic, and body\kinesthetic intelligence. All of the steps in the hierarchical learning will be taken. The students learn how to think. They learn thinking about thinking, (meta–cognition), form concepts through categorizing, organizing, and making fundamentals for generating and testing hypotheses, anticipate future events through inquiry into the past experience, attain concepts formed by scholars. They study through methods of science and they inquire strategies of the sciences, learn scientific thinking, get the facts straight, and enhance creative thought. They activate learning from lectures, readings, references, and databases. The teacher modulates teaching to ensure that all students' learning styles can grow. Cognitive development in learning is the result of this dimension.

3– The personal dimension– With regard to this dimension and the personal models of teaching, as its sub–sets, a wide range of objectives can be achieved. The teacher emphasizes more on the interpersonal, verbal\linguistic, musical\spatial, and body\ kinesthetic intelligence. All of the steps in the hierarchical learning will be taken. The students release personal energy, rise self–esteem and self–actualization, and competence to educate themselves, become able to create and reach toward their personal stars – living so as to grow–and grow, and grow.

4– The behavioral dimension– with regard to this dimension and the behavioral models of teaching, as its sub–sets, a wide range of objectives can be achieved. Breaking down complex objectives into smaller pieces, providing opportunities to learn and frequent knowledge of results, the teacher emphasizes more on the verbal\linguistic, and body\kinesthetic intelligence. Through mastery learning, programmed instruction, tasks and reinforcements the students can learn, unlearn and substitute productive patterns for those behaviors that do not work well.

There are more than 1000 sources available related to methodology and learning methods. The model presented here is the result of the long time study on learning and instruction. Also, in fifteen yearly program of its application the model has been used in teaching and instructing at different levels, grades, and academic subjects instead of current lecture domination. During this time the evolved model has been put into practice in more than 100 educational workshops on teaching subject, and during this period each workshop has brought new innovations in its completion. The two latest ones were conducted at two provinces level i.e., Esfahan and Kermanshah in 2000 and 2001. Over two hundred of educators were participated in these 5 days workshops and their attitudes surveyed were highly positive. The author, also, has a successful experience, as an advisor, with many graduate students in implementing many aspects of the model. At the same time other parts of this model has been presented in many national and international conferences (such as 9th Symposium of the ISOTE, Durban, South Africa in 1999).

Designing CMTSLS Model

This model has application for all courses and is now a baseline for a series of researches done by graduate students in the educational field under the author supervision. In this article one of the teaching subjects i.e., THE POEM "FOUNTAIN AND THE STONE" in reading at fifth grade elementary school will be presented as an example. The stages of its application is as below:

1– Teacher guides the students in order to study individually. They, as a community of learners, can read the text, use new possibilities such as Internet, CDs, computer softwares, books or magazines, and, even interviewing with students and the other individuals on the characteristics of fountains, stones, rocks, mountains and the other keywords for collecting data before presenting it in the class. The learning environment has to be organized and prepared for such activities.

2. Teacher provides an advance organizer informing generally what they are expected to learn from the lesson. "Students are let in on the secret of the structure, including an understanding of how it continually emerges through further inquiry, so that the mind can be active as the course progresses (David Ausubel to Bruce Joyce November 1968). The teacher in the lesson expresses this sentence:

You have faced with many problems so far and have decided to solve them but the solution that you choose may be different and here we want to think about the solutions that "the stone" and "fountain" may think of in order to solve their problems. Imagine *that you are in their place and remember that such problems may happen in your own life, then, what are the alternatives. What is the best solution? In this lesson we practice and perform these solutions and besides we memorize this poem and learn its meaning by heart. Who would like to play the role of fountain, the stone and the mountain? Meanwhile all the groups should be prepared to sing together all the verses whenever I mention and your movements must be adjusted with the meaning of the poems."*

3. Teacher exposes the verses of the poem using overhead or the text concerning verbal\linguistic intelligence of the students.

4. Students will read the text (poem) on screen all together after they have heard the right way of reading and singing it.

A fountain separated from a mountain
Was blocked by a rock and stopped.

5. By accepting different roles for playing, the student give movements to the words comprehended. While they are singing the poem, one of the students plays the role of the fountain that has been separated from the mountain and moves toward the stone. Students use their musical and rhythmic intelligence by producing the voice of the fountain or slamming their fingers on the their palms and giving rhythm to their readings through which they associates the idea of the sound of the water in the class.

6.when the fountain reaches the stone, the teacher makes him (the student) stop and asks the audiences (other students) to put themselves in the place of the fountain and asks them to write their behavior toward the stone if they were the fountain. He/She asks: "What would you do if you were in the place of the fountain? How many alternatives we have to solve this problem make a list of them". Then she/he continues, " Now we would better to choose two groups and have them write their ideas on the board". In this way this teacher and the students are involved with the process of concept formation, collecting information, dividing duties, producing principles and theories, reflections, planning and organizing and managing. These skills are thought to the students.

7. After collecting the student's ideas according to their group projects the teacher asks them to choose one of the roles of the stone and the fountain and make a picture that shows their case. She/he asks the students to show the mood of the stone and the fountain in their faces.

8. The teacher points out that now the poet who has found many solutions, has found a way to discuss the matter with the stone calmly. Then the next group read another verse together:

Calmly it said to the rough stone

Be kind and give me a way out

Students continue and find all the solution that the stone will suggest the fountain and act in them.

CMTSLS AND ITS APPLICATION TO TEACHING FIFTH GRADE ELEMENTARY SCHOOL ON LITERATURE

Teacher's activity	***Learning Objective***	***Model of teaching***	***Student Activity***	
1-Guides individual study	**Knowledge**	**Advance organizer**	**Search for information**	**Verbal/linguistic**
2-Informs general expectations	**Knowledge**	**Advance organizer**	**Reading in groups and playing roles**	**Verbal/linguistic**
3.exposes the verses	**Knowledge**	**Advance organizer**	**Reading**	**Verbal/linguistic**
4.Lets the student start reading	**Knowledge**	**Advance organizer**	**Reading**	**Verbal/linguistic**
5.provides roles acceptance	**Comprehension**	**Role playing**	**Students play roles and simulate movement**	**Musical/rhythmic**
6a-Stops fountain facing the rock. Asks for students' reactions	**Application**	**Inductive**	**List their alternatives putting themselves in its place**	**Intrapesonal**
6b.Asks for classifying students' alternatives	**Application**	**Inductive**	**Classifying the enlisted alternatives in groups**	**Interpersonal and logical/ mathematical**
6c.Asks for giving a title to each concept.	**Application**	**Inductive**	**Chose a title for each class of alternative**	**Intrapersonal**
6d.Asks for finding the features of each alternatives	**Analysis**	**Inductive and interpretation**	**Finding the features of each alternative in each class.**	**Intrapersonal**
6e.Asks for making a table for the features	**Syntheses**	**Inductive and interpretation**	**Make table for the features and the alternatives**	**Logical\mathematical**
6f.Asks for defining the concept	**Syntheses**	**Synectics**	**Make connections between the features of each in their definition**	**Logical\mathematical**
6g.Asks for predicting a new alternative.	**Judgment or evaluation**	**Inductive and application of principles**	**Make prediction on the bases of the definition**	**Logical**
6h.Asks for supporting the prediction	**Application**	**Jurisprudential**	**Determine the features of the alternative relating it to the definition**	**Logical**
6j.Asking experiment	**Application**	**Mastery learning**	**Play the real alternative and documenting their prediction**	**Logical**
6k.Asks for drawing a picture	**Judgment**	**Mastery learning**	**Draw a picture showing their alternatives**	**Visual/spatial**

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The Influence of Modelling of Biological Structures and Processes on the Effects of Teaching Genetics

Katarzyna Potyrala, Pedagogical Academy, Krakow, Poland
potyrala@wsp.krakow.pl

Halina Wojciechowska, Jagiellonian University, Krakow, Poland
rlwojcie@cyf–kr.edu.pl

THEORETICAL BASIS OF THE RESEARCH

The aim of each contemporary school is to equip its students with systematised, permanent and operative knowledge and to create appropriate conditions for them to expand it themselves. To achieve this aim particular models of teaching and learning are used and carried out consistently. This is true of every branch of science. Genetic issues, which constitute the basis of knowledge of heredity and changeability of organisms, are considered to be one of the more difficult in the teaching process. This is because they deal with sub–microscopic structures and the complicated processes which take place in them. On the other hand, these issues are very important in the shaping of biological awareness of the next generation. Fast development of technology creates new and more advanced research tools, on which the development of science depends. The end of the 20th century was a time of great discoveries in the area of genetics and the development of biotechnology. On the one hand, this creates enormous opportunities, but on the other, may result in serious danger. Society in the 21st century should be aware of both. In this context, the importance of academic knowledge concerning genetics has increased even further. Questions arise concerning its place in syllabuses of particular phases of education, its range and also the methods by which it is taught.

Not rejecting traditional methods, we are still looking for new, participatory classroom activities and sources of information other than books. The development of technology provides both, in the form of numerous computer programs. The analysis of literature concerning the use of computer programs in teaching biology helps us to conclude that they have a positive influence on the effectiveness of teaching (Unterbruner 1999, Kross 1999, Ohly 1999, Pfligersdorfer 1999). The primary condition of an appropriate use of a computer program is its introduction into the teaching process as an element assisting the teacher.

There are at least two ways of using computer programmes at schools:

Computer assisted instruction (CAI) and computer managed instruction (CMI) (Kupisiewicz, 2000).

During the selection of computer programs attention is most often paid to their scientific quality, adjustment to a given phase of education and the intellectual abilities of students. However, no research has been carried out into the appropriateness and ways of using computer programs while tackling particular syllabus issues.

Programs related to genetic issues are used willingly in the teaching of biology in the hope of solving problems connected with their understanding.

Years of school experience and research on the effectiveness of methods used in teaching genetics (PotyraÑa, Wojciechowska 2000), entitle the authors of this article to state that while tackling genetic problems, we can achieve better results using traditional methods and teaching aids, i.e. modelling and models (Greb 1957, StawiÚski 1977, Palka 1992, Wojciechowska 2000). Computer programs may be used as a supplement to the above methods. Thanks to their attractiveness they should increase the effectiveness of teaching.

To check this, preliminary research was carried out between September and November 2000 in Secondary School No.10 in Krakow.

METHODS OF RESEARCH

A part of the curriculum was selected from the syllabus for the first year of secondary school (2nd level of education). This part, from the area of cytogenetics, concentrated on the structure of the nucleus, the structure and functions of nucleic acids, the structure of the chromosome, the process of mitosis and meiosis, and basic genetic terms. 8 teaching hours were allocated to covering this part of the curriculum.

Students attending six first forms were selected for the experiment (students aged 15 –16) in one school with an identical syllabus in biology carried out by one teacher.

Students from particular forms were randomly divided into control groups (K1, K2) and experimental groups (E1, E2, E3, E4) in which the same curriculum was carried out with the use of different methods:

K1 – modern teaching methods and techniques (problem solving, brainstorming) assisted by a computer program (Prószyński i S–ka).

K2 – traditional teaching methods and techniques (lecture, talk, working with books, using charts, tables and ready–made models)

In experimental classes traditional teaching methods were combined with modern ones. Computer assisted teaching was used alongside models and modelling which aimed to explain complex biological structures and processes.

On covering the part of the curriculum within the range of the experiment an achievement test was administered. It consisted of multiple choice questions which checked the level of knowledge and ability.

Table 1 presents numbers of students in particular forms in which the research was carried out.

Table 1.

	Form A	Form B	Form C	Form D	Form E	Form F
Number of students	30	33	31	37	33	31
Category of each form	E1	E2	K1	K2	E3	E4

THE RESULTS OF THE RESEARCH

Table 2 presents the results of the test carried out after covering part of the curriculum checked in various ways. The table presents the number of mistakes made by students in particular forms and the average number of mistakes for all experimental classes – E1 –E4.

Table 2.

Question / form	E1	E2	K1	K2	E3	E4	E1–E4
1	1	–	2	10	–	5	1.5
2	–	2	5	13	1	3	1.5
3	1	4	10	20	8	6	4.75
4	3	2	5	7	4	1	2.5
5	2	6	6	7	2	5	3.75
6	1	6	3	14	3	2	3.0
7	–	4	5	9	1	2	1.75
8	1	–	2	11	–	2	0.75
9	2	1	6	10	1	1	1.25
10	2	–	6	18	4	7	3.25

Test questions were concerned with the following issues:

1–2 analysis of a scientific text concerning the structure and function of nucleic acids

3 – selecting the correct definition

4 – completing a diagram presenting the division of chromosomes into progeny cells

5 – specifying the number of chromosomes in the presented kinds of cells
6 – recognising the phases of mitosis in illustrations
7 – knowledge and understanding of genetic definitions
8 – uderstanding the haploid and diploid number of chromosomes
9 – comparing the process of mitosis and meiosis
10 – ordering scientific information

The greatest number of mistakes, and hence the weakest understanding of the material, was observed in K2 control group. What caused most difficulties in this group was analysis of the text and the correct use of basic definitions, which is related to a lack of understanding. Looking at the comparison between control groups and all the experimental ones, we can observe a better understanding of the material in the latter group, which implies a higher effectiveness of the methods and techniques used there. In experimental groups the level of understanding of particular problems, expressed in the average number of mistakes, may imply the lack of major omission in the material, and hence in the understanding of all genetic problems. In the formulation of final conclusions we also took into account comments from the teacher.

CONCLUSIONS

The results of preliminary research allow us to draw some conclusions concerning the effectiveness of teaching genetics, which seem to confirm the authors' assumptions.

Methods and appropriate teaching aids influence the correct understanding of information which constitutes the basis of knowledge of heredity. Using computer programs combined with other methods encouraging student participation gives better results than traditional methods. Applying the modelling method which is based on students' performing certain practical actions with the use of simple materials (paper, plasticine, clay and wire) combined with a computer program seems to be the best way to understand genetic problems. Computer programs, thanks to their attractiveness, cause great interest, activate students, reinforce the information gained and influence the form of its presentation. More time should be devoted to teaching organised in this way.

As far as knowledge concerning genetics is concerned, the order in which information is acquired is also important. Transferring genetic problems from a higher to a lower level (eg. from fourth to first form), as observed in some teacher–generated programmes, is a misunderstanding. It violates psychological and pedagogical criteria and leads to excessive burdening of the child's mind, and consequently, to mental chaos and diminished interest in this branch of science. The teaching of new information concerning genetics should be introduced gradually, on the basis of reinforced, thorough, basic knowledge.

The authors are aware of differences in the abilities of students from different forms which could have influenced the results of the experiment, and therefore they intend to continue the initiated reserach on a wider scale.

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The Balanced Curricula for Science Education

Aarne Tõldsepp, Vilja Toots,
Estonian Association of Chemistry Teachers, *toots@tdl.ee*

The purposes of science education, as a component of young people's whole education experiences, is to prepare them for a full and satisfying life in the world of the 21st century. Realizing of the main aim of science education in the new millenium is to prepare future citizens' demands by compiling of the new strategies as well as the new methodology of teaching and learning including the new curricula and syllabi.

As the formation of STL is one of the main goals of science education it might usefully be taken to the means of developing the ability to creatively utilise science knowledge in everyday life, or in a career, to solve problems, make decisions and hence improve the quality of life. This is based on acquiring educational skills at the intellectual, attitudinal, societal and interdisciplinary levels (J.Holbrook, 1999). Science taught in schools today as well as in future is to enable the students to operate within a scientific and technological society. U. Zoller envisiones the science education as an interdisciplinary critical thinking–, problem solving– and decision making–oriented and, consequently, higher order cognitive skills learning in the science–technology–environment–society interface context, leading to the capacity of transfer beyond the subjects(s) or discipline(s) (U. Zoller, 1999, p. 19). On the ground of the above mentioned theoretical items it is possible to scheme the paradigm of future oriented science education (A. Tõldsepp, 2000).

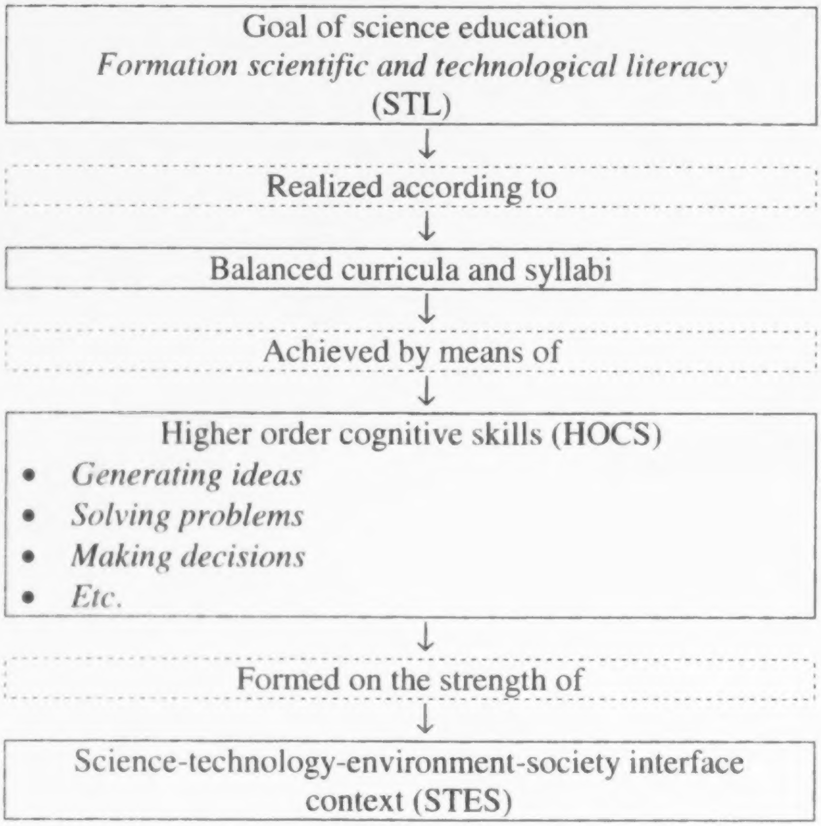
Goal of science education
Formation scientific and technological literacy (STL)
Realized according to
Balanced curricula and syllabi
Achieved by means of
Higher order cognitive skills (HOCS)
• *Generating ideas*
• *Solving problems*
• *Making decisions*
• *Etc.*
Formed on the strength of
Science-technology-environment-society interface context (STES)

Figure 1. Future oriented paradigm of science education

We consider the ideal paradigm of science education today as well as in future the teaching balanced science according to balanced curricula and syllabi in strongly social context based on psychological and didactical treatment. There should be balance between

- governmental and nongovernmental education;
- formal and informal education;
- subject oriented and student oriented teaching;
- algorithmic and nonalgorithmic activities;
- objectivity and attractivity.

Balance should decisively be established between formal and informal issues in any science course. The majority of the postsocialist countries are still oriented on formal issues taking into account only the requirements settled by governmental curricula and syllabi. However the information of STL has got to help young people to acquire a broad general understanding of surrounding world, ability to observe, describe and explain the substances, materials, processes etc. around us in terms of science. STL will be formed only in case that two important considerations – relevance and motivation are governed. How to make science teaching relevant? J.Holbrook suggests that relevant education is related to issues or concerns within society. This could relate to environment, health, energy needs, population control, industry, and communication or to more global concerns geared global warming (J. Holbrook, 1999).

According to the requirement of relevance we see a number of advantages of informal science teaching and learning aimed by the formation of STL. Common everyday observations, conversations, and discussions with parents, friends, teachers, coaches, etc. in school, at home, in living area, supermarket, sporthall etc. provide the students with the facts and experiences needed to generalize in terms of science. In any case science teachers choose additional content from very different sources that help students learn intended outcomes. For example, teachers use local data and everyday information to change teaching and learning more relevant and motivated. The science teachers should find the optimal strategy how to relate everyday knowledge and experience to formal curriculum requirements. Among the different possibilities we see the simplest way of compiling written reports, essays, diagrams, tables and other written tabular or graphical forms. As our empirical studies have shown the students compiled their written reports very objectively, honestly and emotionally. Therefore we can consider the students' written reports as an evidence of their everyday experience, family habits, traditions etc. (V. Toots, A. Tõldsepp, 2000). It is obviously inevitable to establish two major types of science education and two different curricula as was suggested by J. Holbrook (1999):

- that which provides a background for futher study, especially when specialising;
- that which enables a person to operate within a scientific and technological society.

Such curricula are deemed relevant when they meet the needs of students who are striving for multidimensional STL. While such curricula need to incorporate the cognitive, attitudinal, societal and communication components, the needs of students are culturally bound and hence context will differ in substance from one location to another (J. Holbrook, 2000).

Our school needs today as well as in future the balanced science courses. Any curriculum of science education should consist of three components including relationships between these components (see figure 2).

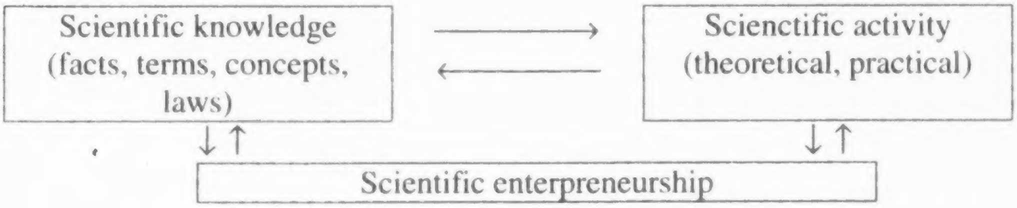
Scientific knowledge (facts, terms, concepts, laws)
Scienctific activity (theoretical, practical)
Scientific enterpreneurship

Figure 2. The model of balanced science (Benchmarks for Science Literacy, 1993)

Nobody can understand science without understanding the history of science, psychology of scientific discoveries, language of science, methods of scientific research and social aspects including enterpreneurship.

In addition to the above mentioned balances we see balance between all educational goals (cognitive development, personal attributes, societal attributes and communication) signifying the curriculum intention in the framework of the formation of STL and between educational components (creativity, analytical and critical skills, evaluative skills, social skills, communicative skills, mathematical skills, learning skills). Compiling of balanced curricula for science education should begin from establishing balance between educational goals aimed by the formation of STL. Science education is achieving educational goals through a context of science. This is put forward as a very important deviation from goals of science education that are seen as putting forward science education as simply a body of knowledge (J.Holbrook, 1999).

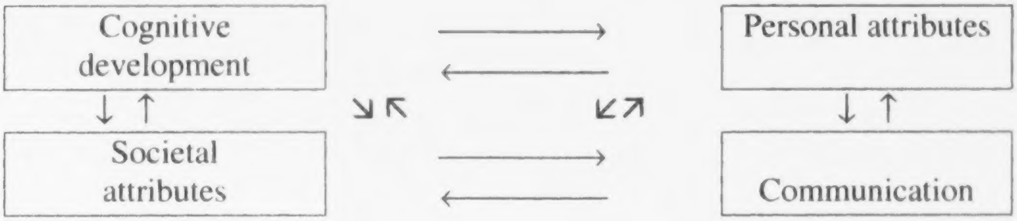

Figure 3. The model of balanced goals for the formation of STL

In different national standards of compulsory education we can see very different approaches to weighing the importance of education goals. J.Holbrook and M.Rannikmäe (2000) summarizing the experts opinions on the importance of the objective areas bring out the following numbers:

Intellectual (cognitive) – 45%
Communicative – 20%
Social and Moral – 10%
Personal and Physical – 15%
Aesthetic – 10%

From the national standard for compulsory education of Latvia (1998) we find that communicative, social and evaluative (moral and aesthetic) skills have in science education, especially in teaching physics and chemistry only a little value. These are such general abilities and skills the development of which should be paid attention to, but which is not the main task of the given subject. Opposite to these objective areas the experts evaluate very highly analytical and critical skills in teaching science. The last point of view agrees entirely with the above mentioned experts' opinions referred by J.Holbrook and M.Rannikmäe. It is obvious that most postsocialist countries must raise the role of communicative, social and evaluative areas in science curricula and syllabi.

Acquiring communicative skills means the ability to communicate using verbal, written, tabular, symbolic or graphical forms. The formation of communicative skills is usually considered as a problem of teaching languages. However chemistry has its own special language of symbols, formulae and chemical equations, the role of the communicative skills among the goals and content of chemistry teaching is much more important than is described in science curricula. The language of chemistry has got its own syntax, semantics and pragmatics too. In addition to acquiring the symbols, formulae and chemical equations (to read, write and understand) every student can use the periodic table of elements, the table of solubility, activity series of metals; every student can describe graphically experimental data about solubility, energy changes etc.

Cognitive development is the ability to think conceptually, plan investigations and the ability to make rational and independent decisions. Every 8th grade student should understand and explain the difference between atoms and ions, pure substances and mixtures, physical and chemical changes, oxidation and reduction, oxides, acids, bases and salts etc. Every 9th grade student should understand and explain the nature of energy changes occurred together in different chemical processes including burning, dissolving, breathing, decaying, fermentation, corrosio etc.

Personal attributes are creativity, ingenuity, perseverance as well as initiative, reliability and positive attitudes. To the personal attributes belongs the ability to take into account the properties of the substances as well as the pecularities of chemical processes in everyday life for improving dietary, leisure etc.

To social attributes belong abilities to identify and cultivate ethical values, a concern for the community, to develop general social skills. From point of view of chemistry teaching acquiring the societal attributes shows that the students understand the role of producing and practical applications of different natural resources such as air, water, metals, fuels, for sustainable development of society.

Realizing the balanced curricula and syllabi demands the compiling of balanced instructional system including balanced strategies and methodology for teaching science. Restructuring a model the relationship between curriculum and instruction in a technical apprioarch (E.J. Sowell, 1996) we offer the following model (see figure 4) for compiling the balanced instructional system.

The main thesis of balanced instructional system should include (Zoller, 2000):

- interdisciplinarity as a core element in science teaching;
- formation of higher order cognitive skills;
- alternative assessment methodology.

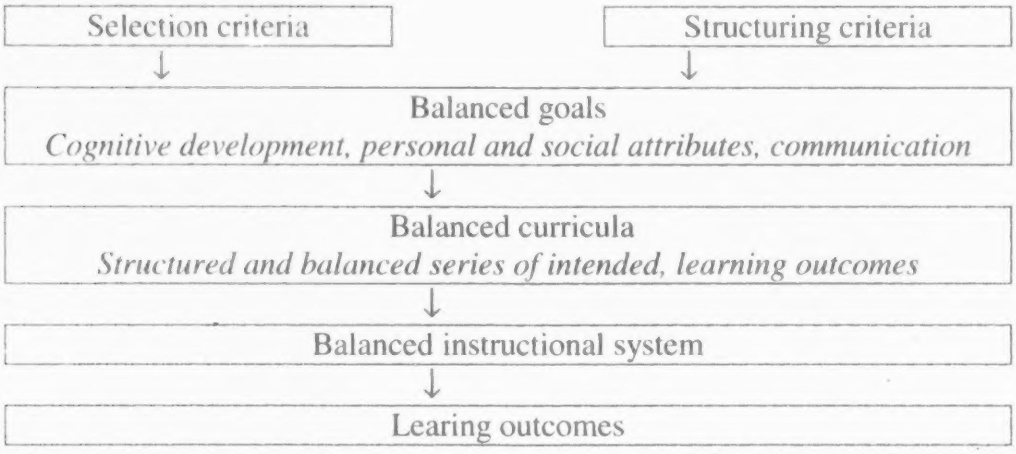
Selection criteria
Structuring criteria
Balanced goals
Cognitive development, personal and social attributes, communication
Balanced curricula
Structured and balanced series of intended, learning outcomes
Balanced instructional system
Learing outcomes

Figure 4. A logic of constructuring the balanced instructional system of science education.

SUMMARY

We consider the ideal paradigm of science education today as well as in future the teaching balanced science according to balanced curricula in strongly social context based on psychological anf didactical treatment. There should be balance between governmental and nongovernmental, formal and informal education, between subject oriented and student oriented teaching, algorithmic and nonalgorithmic activities. In addition to these balances we see balance between all educational goals (cognitive development, personal and societal attributes and communication) signifying the curriculum intention in the framework of the formation of STL and between educational components (creativity, analytical and critical skills, evaluative skills, social skills, communicative skills, mathematical and learning skills). Compiling of balanced curricula for science education should begin from establishing balance between educational goals aimed by the formation of STL.

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Technical Vocational Education in Greece: A Review of the 1998 Reform

P. G. Michaelides, University of Crete, *michail@edc.uoc.gr*

Keywords: review, technical vocational education

Technical Vocational Education (TVE) in Greece was almost exclusively an activity of the private sector of education until mid 70's. In 1976 public schools for Technical Vocational Education were formed and, with time, became the schools for the vast majority of technical vocational students. These post–compulsory education level schools were organized in two distinct paths. The first was a lower level TVE school with study duration of two years. It included the Technical Vocational Schools (TES) and was classified as level 2c in the ISCED 97 classification scheme[1] (comparable to the lower secondary school). No provision for further (technical or vocational) education was foreseen for the leavers from these schools on the basis of their diploma.[2] The other path was an upper level TVE school with study duration of 3 years and it was classified as level 3b in the same ISCED scheme (comparable to the upper secondary education). It included the Technical Vocational Lyceum (TEL), the Unified Multbranch Lyceum (EPL) and other special schools. These schools were under the supervision of the Ministry for Education. The Organization for the Workforce Employment (OAED) operated Apprenticeship Schools, formally classified in the lower TVE level, where teaching was equally divided between school and enterprises where students work as apprentices. There were also other technical vocational schools, mostly unclassified, under the supervision of other ministries[3] and various private schools in one of the previous categories. There was no continuation link between the lower and the upper TVE levels whose operation was often confused with the corresponding initial training and also with the re–education and retraining, even with the (informal) continuous training for the acquirement of new skills. This confusion is still present and affects the organization[4] and operation[5] of the technical vocational education. That organization remained intact in its philosophy until 1998. With the 1998 education reform[6] the technical vocational institutes (TEE) were introduced in a unified path of TVE organized in two consecutive cycles, a clear improvement over the previous scheme. The 1st cycle with study duration of two years concludes with a lower technical or vocational diploma in the education level 2b (assistant). The continuing 2nd cycle with study duration of one year concludes with a diploma of an ISCED level 3b (technician). These types of TVE schools replace completely all the previous types of the classified technical vocational schools. Within this 1998 reform all previously officially classified lower level TVE schools,[7] in the public or in the private sector, were transformed into 1st cycle TEE and they must operate with the new upgraded structure. The schools under the supervision of other ministries may be upgraded into TEE of the 1st cycle operating under the joint supervision of the Ministry for Education and the host ministry, if the supervising Ministry forms new curricula, approved by the Pedagogical Institute. New TVE schools (TEE) may be formed but the corresponding Ministerial decision regulating the operational requirements is still pending. Referring to the operation of TVE before and after the 1998 reform, we note the following:

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[1] International Standard Classification for Education revision of 1997 form UNESCO (151E×8 Annex II). In relation to the Greek education system this taxonomy corresponds levels 0 through 6 to no education, primary education (dimotiko), lower secondary (gymnasium), upper secondary (lyceum), post–secondary non–tertiary (e.g. IEK, if they were classified), tertiary education (first degree or diploma and 'master') and doctorate correspondingly. For levels 2, 3, 4, 5 there is a further differentiation to (a) general with possibility of further education, (b) technical with conditional possibility for further education and (c) technical without formal possibility of further education (not applied to level 5). In European Union another taxonomy is often used for TVE according to a 1984 directive with levels 1 (assistant), 2 (technician) and 3 (expert).

[2] But they could use the leaving certificate from lower secondary school, a requirement for the enrollment to any of the formal lower level TVE schools and enroll to any upper secondary school (lyceum). They could also enroll in the second class of the upper TVE school (TEL) for a relevant to their diploma specialty.

[3] E.g. assistant nurses by the Ministry for Health, apprenticeship schools by the Ministry for Communications, probation officers by the Ministry for Justice, etc.

1. *Specialties*. The lack of institutional Technical Vocational Initial Training[8] in Greece

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[4] For an extended review see: 'Vocational Training in Greece: A summary', Iraklio 1996, and 'Vocational Training in Greece. Part 2.– Two Case Studies', Iraklio 1997. Studies realized within the EU financed project 'Crivet Unemployed. The effectiveness of labour market oriented training for the long–term unemployed' – a Targeted Socio–Economic Research (TSER) project (see in *http://www.cordis.lu* with keyword crivet).

[5] See more in 'The Laboratories of the Unified Multibranch Lyceum' Iraklio 1994, an assessment study commissioned by the Greek Organization for Vocational Education and Training (in Greek). A part of it may be found in 'Informatics in the Greek Unified Multibranch Lyceum' proceedings of the 2nd Panhellenic Conference for the Didactics of Mathematics and Informatics in Education, Nicosia 1995 (also in Greek).

[6] Law 2640/OJ206A/3–9–98 – 'Secondary Technical Vocational Education and other provisions'.

[7] The upper TVE level schools (TEL and EPL) had already been abolished and replaced by general education upper secondary level (lyceum) schools (Unified Lyceum – EL) with Law 2525/OJ/Unified Lyceum (Eniaio Lykeio), access to tertiary education, assessment of education and other provisions.

[8] Technical Vocational Training (initial and continuous) was introduced institutionally in Greece by Law 2009/OJ18A/14–2–92 and Law 2150/OJ98A/16–6–93. Its operation was initially regulated by Presidential Decrees (PD) and the Ministerial Decisions (MD) from the Ministries for Education and for Employment (for initial and continuous training respectively). See for example PD370/OJ210A/5–12–94, and the MD Z/3378/OJ356B/17–5–93, 115372/OJB/11–11–94, 115373/OJ854B/16–11–94, 107797/OJ306B/19–4–95, 108009/OJ308B/19–4–95, 108473/13–5–95, 111456/8–7–96, and 111457/8–7–96.

imposed the necessity for the operation of a great number of specialties (over 200 in total) within the framework of TVE under the scheme before the 1998 reform (old scheme). Overlaps and confusion, especially referring to vocational rights, were common. That history still affects the operation of TVE also under the new scheme. Together with new and modern specialties,[9] there still exist traditional or declining specialties or specialties whose place is within the framework of training (initial or informal).[10] The disadvantage of the old system of the non–correlation of the two levels of TVE of the old scheme has been remedied in the new scheme.

2. *Curricula and Books*. In the old schemes, the existence of a curriculum was rather an exception mostly restricted to a syllabus, in many cases outdated,[11] and often repeating the table of contents of a technical manual. In the vast majority of the courses taught there were no student's books.[12] The Technical or Vocational Profile, the objectives, the aims and the pursued skills were made compulsory under the 1998 reform and have been already prepared, at least for the (new) specialties whose the support from the Pedagogical Institute had been programmed and their design has been concluded.[13] Streamlined textbooks with modern contents accompanied by teaching helps and learning resorts are required and produced specifically for the TVE schools.
3. *Teaching staff*. The diversification on the qualifications, education level and status of the teaching staff is striking. Formal qualifications include graduates from Universities, from other tertiary education establishments (Technological Education Institutions–TEI), from ASETEM–SELETE[14] and also from secondary TVE schools, levels upper (category TE1) and lower (category DE1). The study subjects of the teaching staff cover almost all known areas. Categories TE1 and DE1,

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[9] E.g. CRC–machine tools technician or technician of mechanical farming.

[10] E.g. car–body repair mechanic, assistant cabinetmaker or hairdressing assistant.

[11] For the case of Informatics see 'Problems with the introduction of Informatics in the schools' Proceedings of B' international conference on 'Informatics in Primary and Secondary Education, EPY and Ministry for Education, Athens 27–28/11/1989.

[12] I refer to textbooks officially approved by the Pedagogical Institute and given gratis to the students within the framework of 'a free for all education ('dorean paideia') existing in Greece.

[13] The implementation of the new scheme started immediately from the school year 1998–99 (see MD YA Γ2/5316/OJ1184B/16–11–98, Γ2/5823/OJ1184B/16–11–98, Γ2/5317/OJ1184B/16–11–98, Γ2/659/OJ205B/11–3–99, Γ2/485/OJ155B/24–2–99,Γ2/967/OJ215B/12–3–99, Γ2/438/OJ115B/17–2–99, etc). This rather hasty implementation, together with the existing political situation and the prior implementation of the reform in the general lyceum, imposed some concessions, some of them expected during a transition period, and disclosed the chronic problems of TVE in Greece. Even during 2000–01, third year of the reform a significant number of specialties still operate within the context of the previous scheme.

[14] A post secondary unclassified special school for the formation of TVE teachers especially in the engineering sector.

although at first they were appointed as assistants for the practice work, later they assumed the full responsibility of the laboratory or workshop teaching. This point is still under a transition period with the objective of having only highly qualified tertiary education graduates as TVE teachers and gives rise to operation problems.[15] There are no data on the actual competence of the teaching staff and its teaching sufficiency. The 'yearbook' method of appointment of the teachers[16] and indirect evidence from other works[17] indicate that here is an area for great improvement.

4. *Students.* The lower level TVE schools (TES) were chosen exclusively by students seeking a Technical Vocational Education, often to continue a business in the family. In the upper level (TEL and EPL) student motivation was divided between those who wanted to study for a vocation and those who chose TVE as an alternative path to higher education. Due to social attitudes, in both levels, TVE was chosen by students with low marks in middle school, a fact making teaching a very difficult task.[18] According to available statistics, this year (2000–01) the number of students in TVE raised to match that in general education as compared with a corresponding 3 to 7 previous ratio. It is still a question if this is due to a change of attitude due to the improvement of TVE or to a more selective general education that keeps the more gifted with the rest pushed out.
5. *Equipment and Infrastructure* is a problematic situation. In many cases equipment and the infrastructure relevant to practice work was missing. Sometimes, 'heavy' or expensive equipment is not used because of lack of space, lack of skilled personnel,[19] pending a repair or other operational reasons. Maintenance (preventive or occasional) was not foreseen in an institutional way. The new scheme includes provisions for the remedy of this situation but it is still under implementation.[20]
6. *Counseling and Guidance.* Only recently counseling and guidance related to the vocation is introduced in a systematic way together with the operation of the 'obser-

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[15] The rather political puzzle of 'teaching assignments' i.e. which teacher category takes precedence on the teaching of the different courses. This precedence depends heavily on the obsolete by now but still vivid classification of the course as technical or practical and as theoretical or general (usual).

[16] To be completely replaced by selection examinations from the year 2003.

[17] See for example reference in note 5.

[18] The formation of public TVE schools in mid 70s was ministerially presented as an alternative to those who could not follow an academic education career. This stigma of academic failure is still widely associated in Greece with the students of the TVE schools. The reform tries to reverse the widely adopted feeling that the students in TVE schools are 'children of an inferior god' (see the relevant comments on the curriculum organization).

[19] The actual qualifications of the teaching staff (see previous point 3) rarely include a sound competence for practice work teaching using modern methods and equipments.

[20] See more in P. G. Michaelides, 'Practice work in TVE schools in Greece', work presented in the Pedagogical Institute of Greece Conference on 'TEE – Role and Perspectives', Delphi 30–31 October 2000.

vatory of the transition to the labour market'.[21] Apart from facilitating the social acceptance of TVE, these measures are expected to improve the student profile, especially their motivation, within each TVE specialty, leading to a more effective technical or vocation education.

7. *Recognition and Vocational rights.* In most cases vocational rights were not explicit, pending ministerial decisions. This is a common situation in the old scheme and in the 1998 reform. Under the new scheme, the diplomas in the 1st and in the 2nd cycle are planned to be certified with respect to its education level by way of prefect wide (for the 1st cycle) or nationwide (for the 2nd cycle) common leaving examinations on the core subjects of each specialty. However this provision is not implemented yet.
8. *Further Education.* Apart from the possibility to continue from the lower level (1st cycle) to the upper level (2nd cycle), the 1998 reform includes provisions to further technical or vocational education, in a post–secondary or a tertiary level, for the diploma graduates of the 2nd cycle. This provision was implemented for the first time in the year 2000–01 in a rather unsuitable way and is going to change from next year[22] when the second cycle diploma will enable the owner to enter the workforce, and also, to continue studies in the same or in a higher level.

The implementation of the 1998 reform of TVE in Greece started immediately after the passing of the relevant legislation without any necessary preparation time. The elapsed three years of its transitional implementation were characterized by a flooding of operational problems[23] that concealed other aspects essential for assessment and feedback actions. However, even from this 3–year 'transitional' operation, some comments on the main features of the 1998 reform have already emerged:[24]

9. *Organization.* In both the two consecutive cycles of TVE, the objects of study are organized into 15 sectors with two or more specialties in every sector.[25] Enrollment

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[21] See more details in the Pedagogical Institute site http://*www.pi–schools.gr.*

[22] Diploma graduates of the 2nd cycle took nationwide examinations on language and mathematics for selection to a non–university tertiary (TEI) department. Before their enrollment they should successfully complete a 6–month study program on mathematics, physics etc. This procedure challenges the upper secondary education level of the TVE schools and is to be abolished. Form next year the enrollment for tertiary (university or non–university) education studies for the diploma graduates of the 2nd cycle TVE schools will be based on the certifying nation wide examinations (see previous point 7) without any preparatory course.

[23] E.g. lack of books, lack of instruction and advice to the teachers, ignorance of the new orientation of TVE, lack of equipment, etc.

[24] What follows are personal opinions based on the active monitoring of the operation o TVE in Greece during these years.

[25] The 15 sectors are: the Engineering (the most popular with the TVE students) the electrical, the electronics, the arts and crafts, the textile and wear, the silver–, gold–smith and horology, the musical instruments, the construction, the finance and administration, the agronomics, food and environment, the health and providence, the chemist of laboratorial applications, the nautical and marine, the informatics and computer networks, the cosmetology and the cosmetology and hairdressing. For these 15 sectors 150 specialties in total for the two cycles are anticipated of which about 90 operate already throughout Greece.

to the second cycle is open only to those holding a lower cycle diploma of a relevant specialty within the same sector.[26] Due to the history of TVE in Greece, this, right in its principle, organizational scheme, suffered from some disturbances. These include the large number of sectors, the grouping, in some cases, of rather unrelated specialties within the same sector, etc.[27] The Pedagogical Institute, responsible for education and the OEEK, the organization responsible for the initial training, must rectify this weakness with coordinated actions. The separation in two consecutive cycles for all the sectors exhibits an administrative simplicity imposes however a great challenge on the curriculum and its effective teaching. Consequently, its existence must be well justified. For most of the sectors of the Greek economy, there is no need for the lower level and a three–year upper secondary TVE specialty is a better choice. For other sectors, the operation of lower level TVE schools may, perhaps, be adapted to the needs of the economic refugees living in Greece. In some other cases, the existence of a distinct 2–year lower level and another 3–year upper level may be a better choice.

10. *Curriculum.* The courses taught are divided in two classes, courses specific to the sector or the specialty (specialty courses) and courses of a rather broader nature (general courses). In contrast with the old scheme curriculum, where the teaching objectives were exhausted to the acquirement of some technical skills and to the memorization of technical or vocational facts, the curriculum of the 1998 reform includes also to a large extent subjects from a broader to the study specialty area[28] and focuses on the development of more general cognitive skills.[29] The purpose of these courses is to provide the TVE students with a general background of dexterities enabling them to participate in a modern society[30] and to provide them with the necessary background knowledge and skills enabling them for further education to a higher level, apart from their general usefulness. During the first year, the specialty courses are common to all the specialties within a sector. These courses are traditionally classified as usual courses and as courses with practice (laboratory or workshop) work. For the latter ones, the study program must describe also the minimum requirements in equipment, classroom, practical activities, etc. Although in

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[26] It is also open to those holding corresponding technical or vocational diplomas from the previous TVE schools.

[27] See also the previous comment in 1.

[28] These include courses on the work context, computer usage and applications, learning of a foreign language, as well as courses on language, mathematics, physics, history etc. to about 1/3 of the curriculum.

[29] TVE teachers are explicitly instructed to try and achieve the teaching aims by involving the students in problem solving and decision making activities. Even the practice for the acquirement of technical dexterities is advised to be with moderate only instruction permitting the student to exhibit his/her own initiative and ingenuity.

[30] This is a very important point because, in most developed societies, about 7 out of 10 of the young enroll in TVE.

many cases, courses are organized with the teaching of the 'theory' and the 'practice' interwoven, this matter must be regulated firmly on the basis of pedagogy principles alone taking into account the widely diverging requirements (in equipment, supervision, classrooms, safety, etc) of the practice (laboratory or workshop) work between the different courses.[31] The stipulation of 'Laboratory and Workshop specifications' is a matter of urgency.

11. *Syllabus and Books.* With the formation of new modern curricula (see previous point 2) the syllabus was also updated and greatly improved. New books are specifically prepared to be used as teaching books. They are accompanied by guides for the teacher, laboratory and drill guides (if applicable) and other material and other resorts supporting teaching. Their use revealed points for improvements such as error correction and synchronization between the syllabi between courses with interdependency. Another complain however was that their level was too high for the students in the TVE schools. It is a matter of further investigation if this is an actual drawback or it is due to teaching deficiencies (see also next comment on the teaching staff).
12. *Teaching Staff competency.* The operation of the new TVE curricula revealed that although in general the teaching staff responded adequately to the higher demands of the reformed curricula in a number of cases there was a real problem. The syllabus was of to high a level for a significant percentage of the teaching staff, especially for the courses in the engineering sector that refer to modern equipment and techniques. An even higher percentage lacks the necessary skills for a modern TVE teaching (see also last comment in point 3 previously). It seems that there is a need for an extensive in service training.

Despite the problems mentioned earlier that are expected to rectified in due time, the 1998 reform of TVE schools in Greece exhibits clear improvements over the old scheme. The most prominent improvement is the possibility of further education, a feature compatible with the quest for personal development and an essential constituent of an education for all providing all the citizens with the means for an active participation in the modern society. This feature is enhanced further by an improved curriculum organization. The provision for general courses of a broader nature may be used also to deal also with the basic aspects of some concerns of the modern society such as the environmental impacts from the use of technology, the sustainable development, the energy consumption etc. I note that under the previous scheme, in the lower level TVE schools (TES) with the majority of the TVE students there was no provision at all for this kind of courses, while in the upper TVE schools (TEL and EPL) this type of course was predominant. As a consequence in both levels there was an imbalance towards opposite ends between the technical or vocational dexterities acquired and the more general education, necessary for future citizens.[32] The new scheme tries to restore the balance. It remains to be proven from its application.

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[31] This resolution was introduced for administrative easiness focusing on the type of practice work encountered in the engineering section with the heavy equipment. It resulted to a politically sensitive subject relating to the rights of 'teaching assignments' for the different courses (see also footnote 15).

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[32] In Greece the leavers from the lower TVE schools, although their social acceptance is lower, they have much higher employment rates than the leavers of the upper level. Also, their higher levels of employment are within their vocation as opposed to the upper level TVE leavers where their employment is to a large extent in areas unrelated to their TVE education (see the results from the observatory of the transition to the labour market in the Pedagogical Institute of Greece website http://www.pi–schools.gr). This is in contrast with the findings from other developed countries and may be due partly to this imbalance.

Creating Role and Autodidactic Plays for Science Teaching in Primary School

Ani Epitropova, Plovdiv University "Paisii Hilendarski"
ivron@mbox.digsys.bg

1. BACKGROUND, AIMS AND FRAMEWORK

In connection with the process of changes in Bulgarian education due to the fact that the country is eager to join the EC, in 2000 new state educational requirements /standards/ were introduced in Bulgaria concerning teaching science in primary school as well. The new content allows the play–like character in the classroom. It means an ability of making a free choice, a motivated and voluntarily taking part in mutual solving of problems, and doing different cognitive acts in an emotionally soaked atmosphere. Role and autodidactic plays create the above–cited conditions for education.

In the new millennium when one witnesses the total acceleration of life and changes influencing science, technologies and education, it is important for the individual to penetrate in the core of facts and phenomena, to analyse the possibilities, to evaluate the effectiveness of her/his decisions and the consequences that follow.

To achieve that aim it is important for science teaching to be directed mainly towards the development and activating of pupils' thinking. Acçording to a recent pedagogical research we can claim that the opportunities of play for fulfilment of the goal has proved their significance.

The utilization of plays depends to a great extent on the teachers' competence to perform them. Having in minded the inquiries and pedagogic findings concerning school lessons, we can state that too many teachers are not prepared for such form of education. The most difficult problem in practice is that teachers are aware of the significance and the great opportunities of play–relationships in general; but in fact they are unable to give up their traditional mode of teaching. The reasons for that are in:

- Priority using of explanatory–illustrative method as a priority in teaching. It requires less preliminary preparation and spares time.
- The incapability to change the self–apprehension and behaviour.
- The necessity to enrich and reconstruct the knowledge about natural objects and phenomena and their relationship to society.
- The difficulties to create independently games appropriate for a given educational content and the age peculiarities of the pupils.

The establishment of these facts proved it necessary to make a special module for training graduated teachers that aims at raising their competence.

Its content's purpose is to inform the teachers about the essence, classification and significance of plays and how to utilise them accordingly in science teaching in primary school. Besides, it also aims at teachers' ability to create their own plays for the requirements they have so that to develop pupils' thinking and to raise the effectiveness of teaching science.

2. METHODS AND SAMPLES

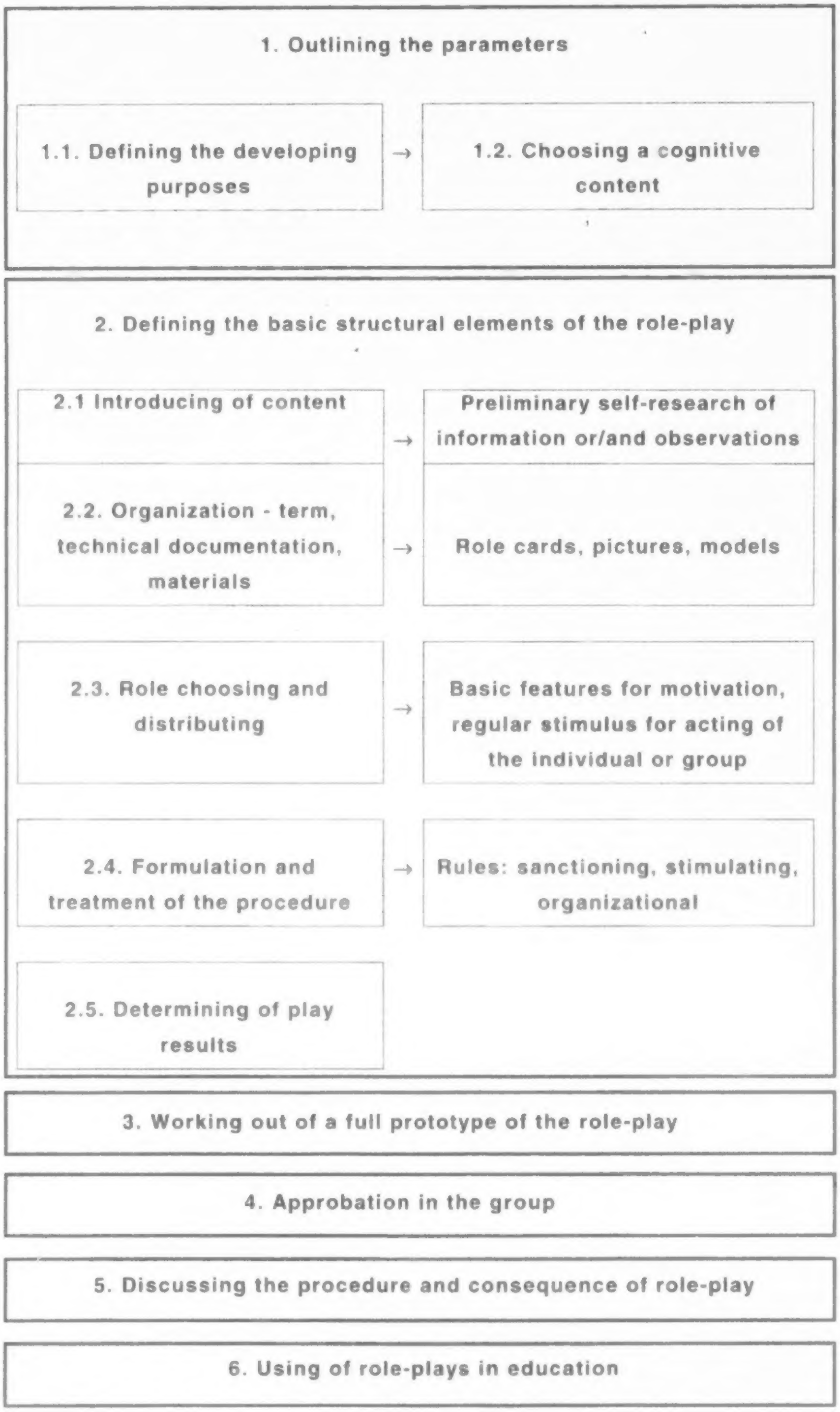
The contents of the module is directed towards the preparation of teachers how to direct and create their own role and autodidactic plays. The point of using them is to develop in pupils the basic mental capacities, to raise the motivation as well as to enlarge their communicative competence.

Here is a presentation of the sequences of the activities in the module:

- Preliminary introduction of the organization, plan and rules of a certain play to a small group of participants. A demonstration of a type of the play is acted and the whole group discusses it in detail. In case there is a lack of information about the components of the play contents, additional investigation is needed.
- The participants act the role-play. This enables the change of positions and viewpoints, regarding the process itself and the place of everybody taking part in it.
- Directing such kind of activity while some are taking the part of the pupils somebody takes the part of the teacher.
- Forming abilities for independent making or adapting already known games for the needs of science teaching at school.

A scheme is presented to show the basic components of the activity.

STAGES IN CREATING A ROLE–PLAY


1. Outlining the parameters
1.1. Defining the developing purposes
→
1.2. Choosing a cognitive content
2. Defining the basic structural elements of the role-play
2.1 Introducing of content
→
Preliminary self-research of information or/and observations
2.2. Organization - term, technical documentation, materials
→
Role cards, pictures, models
2.3. Role choosing and distributing
→
Basic features for motivation, regular stimulus for acting of the individual or group
2.4. Formulation and treatment of the procedure
→
Rules: sanctioning, stimulating, organizational
2.5. Determining of play results
3. Working out of a full prototype of the role-play
4. Approbation in the group
5. Discussing the procedure and consequence of role-play
6. Using of role-plays in education

3. RESULTS

As a result of the application of this method of education one can witness a positive change regarding the self–apprehension and behaviour of the teachers, as well as an availability of motivation to teach using play–relations. The communicative competence is stimulated.

In fact teachers have either enough or appropriate training to reach the main emerging curricula objectives, namely:

1. To integrate the different scientific fields of study (Biology, Physics, Geography and Chemistry) in meaningful topics for young learners;
2. To focus the learning process on the pupils and to develop activities of an experimental and inquiry nature;
3. To include in the teaching process some of the students' sociocultural everyday situations in order to help them understand the importance of starting to learn Science since the early stage.

Regarding the pupils – these plays train them to adapt quickly, to make a critical evaluation of the situation, to take adequate decisions. By the means of the game they become better educated, they are able to extricate the essence of facts and phenomena, to analyse the elements and possibilities, and also to evaluate the effectiveness of their decisions and the consequences that follow.

4. CONCLUSIONS AND IMPLICATIONS

Studying science in primary school becomes more effective by using different teaching strategies for science teaching and learning based on educational research. The eagerness of primary teachers to use games in their work depends not only on the knowledge about the essence of games and the opportunities for their utilisation but also on the behavioural style of teaching. That is why when teachers are ready to use and create games the total result of teaching science is definitely positive. Teachers of science subject develop and improve their own practices, basing on theoretical grounds, experiences exchange, and cooperative creating materials for self and for pupils.

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"Thinking Science" – Developing Cognitive Skills of Low Functioning Middle School Students Through the Use of a Science Learning Program

Yaron Schur, Nir Orion, and Oded ben Mencham,
Weizmann Institute of Science, Rehovot, Israel,
schurfa@netvision.net.il

RATIONALE

Science teaching can be an important and basic tool for teaching students in schools where there are a lot of low functioning and new immigrant students. The process of science teaching should be student centered, with an emphasis on explicit mediation of cognitive and emotional processes. Succeeding in learning up–dated scientific topics can also help in connecting the students to the modern society.

DESCRIPTION OF THE "THINKING SCIENCE" PROGRAM

A special science program, called "Thinking Science", for teaching up dated scientific topics and developing cognitive skills of low functioning students was developed. The program is implemented in middle schools where there is a high concentration of new immigrant students. Many of the students have low expectations of themselves. They feel disconnected from the society around them. The basic principles of the "Thinking Science" program are:

1. From the concrete to the abstract.

The program connects classroom learning with going out to the natural environment. The program relates specifically to the unique natural environment of each school. From observing the concrete environment one goes to learn the basic ingredients of life and of the basic rocks.

The experience of observing a specific environment enables the students to broaden their perspectives. They go out to view their environment in perspective and to understand it as a part of the whole of the earth. They go on a thinking journey to the nearest astronomical neighbor, the moon, in order to return to a specific environment and to observe it now in a new way. The mediation of the encounter of the students with the natural environment and the pictures of the moon includes the use of cognitive skills such as: categorizations, comparisons, analytic perception, reflective thinking and flexible thinking.

2. Concentrating on authentic questions that relate to real life problems that concern the environment.

One of the schools that implements the program is situated near dunes, where a lot of sand is being taken illegally. The students see the trucks coming into the dunes and loading sand without being stopped. They deal now with the question of development against conservation with the point of view of the need to conserve the dunes.

3. Going for excursions as an integral part of the program.

One problem of the students is that many of them don't know their near environment and they have not visited many of the sites that are within few hours drive from their homes. Apart from learning with a direct and constant connection to the natural environment, it is important to let the students go out for excursions and enjoy them. The excursions are connected to science learning, and the students participate actively in them.

4. Projecting the order of the natural environment to that of their everyday environment.

The idea is that by projecting order on the natural environment the students can learn to observe order also in other environments. The program focuses on connecting the natural environment with the students' everyday life.

5. Focusing on the cognitive and emotional needs of the students.

The program includes in it activities factors that relate to the different intelligences of students and to their emotional intelligence. The content and the didactics are chosen in order to enhance the feeling of competence of the students. The teachers are instructed to write tests that emphasize cognitive processes and to let the students get the feeling that they can succeed in science learning.

6. Enabling students to express their curiosity and their special points of view.

When the students go out to the natural environments they take pictures with their cameras. Every group of students has a camera. They focus on the aspects that interest them. Even when they are given concrete instructions like: take a picture of a typical plant of the dunes, they bring a lot of different pictures of plants from different angles. They learn to follow the footprints of various animals.

7. Students learn to observe the environment in a dynamic process.

Some of the students don't relate to the natural environment when they first visit it. When they are requested to draw it, they draw the nearby road and buildings, ignoring the natural components. The first impression by others of the natural environment is of a place that consists of some sand, which does not interest them. On revisiting the natural sites, the impression of most students is replaced by the understanding of the liveliness of the environment. Even the sand is seen from a different perspective. They view the sand under microscope and they see the crystals of quartz, which look like "diamonds". They learn the story of the quartz, which came from far away. They understand the dynamics of the environments. The environment that they see now is a result of processes that occurred for a long period of time. It is interesting to see how the students change the way they observe the environment after experiencing many mediated sessions of different aspects of it. They draw it very differently than in the beginning of the program. They are able to focus on details and to include scientific elements inside the drawings.

THE IMPLEMENTATION OF THE PROGRAM

The program is now in its first year of implementation. Two middle schools teach it, in all the classes of the age group for six hours per week. This year science teachers of an additional six middle schools are in the process of training for the program, and they are going to implement it next year. The implementation process of the program begins with a year of training, 112 hours, of the science teachers of the schools that are going to be involved. The reactions of the directors of the schools, their teachers and students towards the program "Thinking Science" are very positive.

Promoting Scientific Literacy for Future Citizens Through Developing STS Activities

Walter Yu-Jen Su,
National Taichung Teachers College, Taiwan,
waltersu@ms58.hinet.net

I. INTRODUCTION

Scientific literacy is the most highly valued human quality for future citizens and is also one of the most active research areas in science and technology education. It is of utmost importance to develop in students the abilities of problem–solving, decision–making and value judgment. According to National Science Education Standards (National Research Council, 1996), scientific literacy implies the following dimensions: (a) scientific cognition – a person has the ability to describe, understand, explain, and predict natural phenomena. (b) scientific method – a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. (c) communication skills – being able to read with understanding articles about science and technology in the popular press and to engage in social conversation about the validity of the conclusions. (d) decision making ability – a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. (e) critical thinking skills – a science literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. (f) scientific attitude – has a sympathetic attitude toward science and technology, also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately. (g)scientific applications – understanding the nature and importance of science and technology as well as the inter–relationship between science, technology and society.

Science education should help to develop scientific literacy in future citizens who are prepared to deal intelligently with science–related social issues, to influence, where appropriate, policies related to the impact of science on society. In addition, it can also advance the field of science itself by preparing a citizenry that has a sympathetic attitude toward science and a willingness to make use of scientific expertise.

STS (Science/Technology/Society) education addresses learning of science concepts in the context of real life experiences and with application to real life problems and issues (Lutz, 1996). STS teaching provides an appropriate strategy because it focuses on process, not product. STS teaching should involve learners in experiences, questions and issues which are related to their lives (Harms & Yager, 1981).

Wiesenmayer and Ruba (1990) argued that, to many STS advocates, the highest goals of an STS education was social action. Students should be able to identify science-related social issues, analyze the context in which the issues are played out in society, know the key individuals and groups involved in making decisions, investigate these science-related issues themselves, develop an action plan, and implement that plan where appropriate.

A large body of empirical research has demonstrated that the STS teaching provides the unique opportunity for students to find success and satisfaction in their creative endeavor on their own terms. Students in classes taught with an STS approach were able to develop more science creativity skills when compared to students in classes taught with a traditional approach (Mackinnu, 1991). Myers (1988) has carried out practical investigations to suggest that "The STS approach does have a significant impact on students' abilities to apply their science knowledge, to think critically, and in improving their interest in science careers."

STS classroom has following features or characteristics in the learning environment which has much to do with the main components of scientific literacy: curiosity, self–directed or initiated inquiry, insightful questions, personal relevance, cooperative learning by effective communication, and real–situated learning.

The effective and flexible STS teaching strategy addresses six basic steps: (a) brainstorm an issue or topic; (b) define a specific question or phenomenon; (c) brainstorm resources for obtaining information; (d) use the resources to collect information; (e) analyze, synthesize, evaluate, create; and (f) take action.

STS learning was initiated by problem–finding which had been carefully scaffolded by means of scenarios or any interesting vignettes. Once the students had been motivated to investigate autonomously the social issues related to science or technology, the researchers started to guide them in finding problems from different angles in a generative thinking model through brainstorming in small groups. After various problems had been proposed, students were then asked to elaborate on them until each problem became a substantial and scientific problem that could be explored meaningfully.

Yager and McCormack (1989) have identified five domains that are important as "science for all" is discussed. Their domains matches well with important dimensions of scientific literacy depicted above and provide a basis for determining goals, curricular strands, instruction, and assessment for many science education advocates. In accordance with the constructivist learning model, Loucks–Horsley et al. (1990) has proposed an STS instructional strategy which covers those five important areas. Four stages are included in this strategy and they are further elaborated as follows:

(a) The first stage – inviting to learn. Various methods can be used to motivate students so that their curiosity will drive them into adventurous investigation. In the end, at least one or two problems should become their foci of attention which compels them to solve such problems.

(b) The second stage – explore, discover and create. In order to solve their problems, students should be guided to explore in depth the underlying principles and theories relevant to this problem. Once the inter–relation of them are discovered, students may therefore be enlightened to design appropriate instrument or tools essential for solving the problem.

(c) The third stage – propose explanations and solutions. When students have sufficient opportunity of proposing explanations and putting them to strict verification through practical work or empirical investigations, their prior knowledge will be modified or even replaced by new concepts.

(d) The fourth stage – take actions. It is of utmost importance that students try hard to seek practical applications of what they have learned in the real life. Sometimes, teachers should encourage them to take responsible actions in the modern, democratic society.

The STS module is problem–centered, flexible and multi–faced, including local and community relevance. Use of the natural environment, community resources, and the students themselves are seen as foci of investigation.

In short, goals such as promoting scientific literacy should lead to much diversity in what students are doing in the classroom. The STS teacher creates a classroom climate which organizes, stimulates, and makes readily available a wide range of resources and ideas and actions that encourage students to achieve the desired roles and goals of scientific literacy. Creative thinking requires the application of knowledge, a more sophisticated intellectual operation than simply understanding and memorizing what is learned. Therefore, in using STS learning activities, students are actively involved in generative learning rather than just learning information, in other words, they have to construct their meaning to produce meaningful learning (Solomon, 1993).

The module in this study was focused on the Nuclear Chemistry because of two considerations: (a) radiation and radioactivity associated with the radiating steel event has been a hot issue with local relevance in Taiwan recently, and it can provide a good starting point for the clarification and development of general STS literacy. Student interest and motivation may be increased when this personal and local event was introduced. (b) the construction of the Fourth nuclear power plant has been a great disputing public policy issue which provides opportunities for teaching basic science concepts and a forum for encouraging civic participation.

II. METHODOLOGY

(1) Subjects

One hundred and nine students from three freshman classes in the Department of Science Education, the National Taichung Teachers College in Taiwan, were selected as the target sample in this study: 52 females and 57 males. All the students entered the elementary school pre–service teacher program and majored in science education. They were enrolled in the General Chemistry course and their age ranged from eighteen to twenty two.

(II) STS learning assessment instrument

All the tests and instruments necessary to this investigation have been translated and re–designed from the original versions by the SS& IOWA project. Defined by the Iowa – SS & C program (Yager et al., 1997), five domains of science are conceived to be a "whole" and/or "authentic" rationale for assessing student learning in science. This assessment package has conducted some elaboration of the Yager–McCormack domains (1989) and other helpful ways of conceptualizing the domains has been considered as well (Yager & Ajeyalemi, 1994). The five main domains in this assessment instrument are described as follows:

(a) Concept Domain: includes facts, concepts, laws (principles), and existing hypotheses and theories being used by scientists.

(b) Process Domain: some processes of science are observing and describing, classifying and organizing, measuring and charting, communicating and understanding communication with others, predicting and inferring, hypothesizing, hypothesis testing, identifying and controlling variables, interpreting data, and constructing instrument, simple devices, and physical models.

(c) Creativity Domain: some of the specific human abilities important in this domain are visualizing – producing mental images, combining objects and ideas in new ways, offering explanations for objects and events encountered, questioning, producing alternative or unusual uses for objects, solving problems and puzzles, designing devices and machines, producing unusual ideas, and devising tests for explanations created.

(d) Attitudinal Domain: includes developing sensitivity to, and respect for, the feelings of other people; expressing personal feelings in a constructive way; making decisions about personal values; and making decisions about social and environmental issues.

(e) Applications and Connections Domain: some dimensions of this domain include seeing instances of scientific concepts in everyday life experiences; applying learned scientific concepts and skills to everyday technological problems; understanding scientific and technological principles involved in household technological devices; using scientific processes in solving problems that occur in everyday life; understanding and evaluating mass media reports of scientific developments; making decisions related to personal health, nutrition.

(III) Procedure

The cooperative method of learning and instruction developed by Sharan and Hertz–Lazarowitz (1980) was utilized in this study to set up a creative atmosphere through the STS learning. In essence, this method addresses group investigation in a class and the democratic atmosphere when dealing with problems. There are several steps involved in this method: (a) identifying the topic and organizing students in groups; (b) planning the learning task; (c) performing the investigation; (d) gathering the information and collecting data; (e) preparing for a classroom report; (f) presenting the report to the other groups; and (g) evaluation.

During the investigation, the researcher tried to employ several strategies to develop students' scientific literacy through designing the STS learning activities in nuclear chemistry and the experiences acquired by both teachers and students during this process were described in brief. The brainstorming strategy was used to help students find problems for investigation fluently at the initial stage of this study. The students were grouped by members who had chosen the same topic they'd like to investigate. They planned the way they would investigate the subject, and maximum student involvement was assured in their group planning. The teacher acted as a facilitator and resource person. He visited the groups from time to time to encourage social interaction, to foster the mastery of communication skills in students, and to participate without personal judgment.

In addition, the whole processes of students' STS learning activities were observed by the researcher in a naturalistic setting by means of video–taping. The data was treated by using the qualitative interpretation.

III. RESULTS AND DISCUSSION

The main findings from this investigation can be summarized as follows:

□I□The STS learning activity was effective in stimulating students' creativity

After extensive discussion through the brainstorming among the students in different groups, students generated many novel and interesting ideas worthy of investigation. They tended to ask more questions which led them into further explorations and learning activities. Those questions were in general more relevant to their daily life and students seemed to be more interested and deeply involved in such learning activity. In the end, students showed much greater curiosity toward the world around them. During the whole process, students learned to elaborate on their personal problems so that they were finally able to determine possible causes and observe those influences exerted by the manipulated variables.

Among various problems, the following nuclear chemistry units evolved out of corresponding problems were selected to further develop modular activities:

A. Getting to know the radioactivity

(a) The discovery of radioactivity (history of science);

(b) Ionizing radiation around us (local concern);

(c) Radioactivity in the environment (scientific applications to daily–life).

B. Properties of radioactivity
  (d) Nuclear radiation (scientific cognition);
  (e) Radioactive decay (scientific cognition);
  (f) Detecting radiation (scientific cognition and application);
  (g) Radiation doses (scientific cognition and application).

C. Radiating–steel event in the community (social applications of science and technology)
  (h) How did the radiating–steel event happen?
  (I) How to detect the radiating–steel polluted buildings?
  (j) Dose and dose–equivalent;
  (k) The effects of its radioactivity: acute, somatic and genetic effects;
  (l) Radiation limits.

D. Sources of radiation
  (m) Radiation in the nature;
  (n) Radiation in the health services;
  (o) Radiation and nuclear energy;
  (p) Radiation and nuclear arms;
  (q) Radiation at home and in industry.

E. Nuclear energy issue in Taiwan society
  (r) The Fourth Nuclear Power Plant (societal issue)
  (s) The alternative energy (problem solving);
  (t) The facilities and protection scheme of nuclear power plants (interaction between science and technology;
  (u) Risks and safety (decision making).

F. Radiation in the medical science
  (v) Radioactive sources for diagnosis and radiotherapy;
  (w) Medical applications.

(II) Students were actively engaged in generative and productive learning

The frequency of comments, the quality of STS unit activity plan and relevant materials collected, and his/her degree involvement in the class activity of each student were all recorded for evaluating the degree of participation. The mean score of male students was 78.6, and the mean score of female students was 87.2. It appeared that female students were much more deeply involved in the STS activities.

When carrying out the STS learning activities, students employed a wider repertoire of activity types such as: divergent thinking in the brainstorming stage, small group work in data collection and practical work, student–centered class discussion, problem solving, simulations, decision making, controversies, debating, and using the media and other community resources. It is really interesting to see that students were versatile enough to work out their way actively and vividly either in getting across their ideas, convincing or persuading their classmates, or defending their own positions.

(III) Students' critical thinking was promoted during the STS learning

The correlation between the degree of participation and students' open–ended level of thinking is much higher than that between the degree of participation and the written test indicated that STS learning activities had very positive effect on promoting students' open–ended thinking. The conventional written test was not able to reflect students' affective learning outcomes, in contrast, the assessment of the level of open–ended thinking enabled students to re–organize their cognitive structure and integrate what has been stored in their long term memory.

IV. CONCLUSIONS AND SUGGESTIONS

The findings from this study seemed to suggest that such open–ended learning as the STS designing activities is one good vehicle of promoting students' scientific literacy due to possibly helping students develop the confidence and ability to reorganize and create new ideas at the same time as requiring students to complete tasks that are rewarded by deep approaches to learning in designing STS activities. They can be used to encourage students to think about ways of using scientific data because students are forced to decide how data or information can be used critically in society since no explicit goals are predetermined for them.

If students are to communicate effectively and to formulate and follow up on questions, they must have a classroom climate conductive to their development. The teacher plays a key role in creating that environment where personal meaning–making of science and technology is valued, encouraged, modeled, and rewarded. This environment has been well exemplified in our STS classroom which has created a safe environment by accepting, without evaluation, responses to any student's questions and allowed students to evaluate their own ideas.

It is also very important for teachers allowing time for students to reflect upon their experiences dealing with different solution strategies and to share their experiences with other students. Reflection provides students with an opportunity to identify and label what it is that they have learned from their own experiences. Sharing their experiences with other students gives validity to what they have learned.

One goal of science education should be to get students to consider and use creative thinking as a natural part of the way they solve problems. Engaging students in the authentic STS constructivistic learning activities that explicitly require them to represent and solve problems is a practical way to begin pursuing the goal of scientific literacy in different levels of education.

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How to Accomplish Introductory Classes to Teaching Themes at the Beginning of Learning Chemistry?

Jasminka Korolija, Ljuba Mandic, and Biljana Steljic,
University of Belgrade, Yugoslavia,
ljmandic@ helix.chem.bg.ac.yu

ABSTRACT

Introductory classes prescribed by curricula are frequently accomplished only at the beginning of learning a new teaching subject. Such approach does not make provisions for pupils to get insight into the contents (concepts) of teaching themes. Considering that lack of perspective is more harmful than that of terminology, in the present paper introductory classes have been prepared and accomplished for all teaching themes at the beginning of learning chemistry in elementary school.

In preparing introductory classes, key questions were as follows: "What is to be presented during introductory classes?" and "In what way?". To find out the best answers a number of criteria have been set up. On the basis of these criteria the fundamental concepts, crucial for understanding contents of teaching themes (Chemistry and its importance, Basic chemistry concepts, The structure of a substance, Inorganic compounds) were chosen. Some properties of the concepts selected pupils got familiarized with through independent experimental work and demonstration, didactic games and heuristic conversation (modes of accomplishment of introductory classes). Substances from everyday life were used in experiments. Thus, it was possible for pupils to realize that chemical changes take place everywhere, i.e. to notice correlation between what they are taught and phenomena and changes in everyday life, between spontaneous concepts and selected scientific ones as well as correlation between different teaching subjects. During introductory classes pupils were able to participate actively in the teaching process, to develop independence and greater motivation for learning.

Pupils' acquisition of the first information items, perception of concepts' properties and their application in decision–making and conclusion drawing was monitored by means of work sheets. The analysis of recorded responses evidenced that high per cent of pupils (50–80) responded well to the posed tasks related to perceptions and conclusions. The achieved results showed that introductory classes to teaching themes, accomplished through heuristic conversation, exploratory designed demonstration experiments and those designed for independent work provide a good basis for acquiring concepts during their teaching, and no doubt increase pupils' interest in certain areas.

KEY WORDS: introductory classes, teaching themes, active learning

INTRODUCTION

In didactic there are different classifications of classes. According to one of them, made on the basis of the dominant teaching content of a class, distinction can be made between classes of introducing new themes, teaching new contents, revising and reinforcing, systematizing, and checking the level of acquired knowledge.

Methodical instructions for teaching contents of a certain teaching subject most frequently provide schedules of how to teach new themes. New ways of approach to certain scientific concepts are suggested, particularly concerning abstract concepts that junior age pupils (11–13 years old) are to get familiarized with.

In Yugoslav curricula, introductory classes are scheduled to be held only at the beginning of learning a new teaching subject. Such approach does not allow pupils to get insight into the contents (concepts) of teaching themes. Considering that lack of perspective is more harmful than lack of terminology (1), in the present paper the authors have prepared and accomplished introductory classes for all teaching themes in 7th grade of elementary school (the beginning of learning chemistry).

METHODES

Preparation of those classes involved key issues such as: What is to be presented during introductory class? In what way? To find out optimum answers, adequate for four teaching themes, a number of criteria have been set up:

- Selected concepts should be general (basic), i.e. those taught over particular and individual concepts in a teaching theme.
- Pupils are to get familiarized with concepts through independent experimental work ("We are watching, working, explaining, deciding" was the motto of the activity), demonstration of simple experiments and heuristic conversation.
- Experiments selected for demonstration and independent work should be safe, simple, economical, funny, useful, relevant. It is desirable that substances used in experiments come from everyday life. This enables pupils to understand that chemical changes take place everywhere, i.e. to see correlation between what they learn in school and phenomena and changes in everyday life, between spontaneous concepts and selected scientific ones as well as that between contents of different teaching subjects.
- The application of various teaching aids enables pupils to get familiarized with concepts more readily (2). Therefore, didactic games should be thought of, so that work becomes funny and playful (3).
- The selected method of guided discovery, forms of work and teaching aids should make provisions for pupils' active participation in the teaching process, development of their independence and greater intrinsic motivation for learning.

To monitor the degree to which pupils have acquired first information items and applied them to decision–making and conclusion–drawing, work sheets were made, where pupils wrote down their perceptions and conclusions.

RESULTS

Table 1a shows the presented themes, selected concepts, and methods of introductory classes accomplishment.

Table 1a. Introductory classes for teaching themes – review of concepts and mode of accomplishment

Teaching theme	Concepts	Modes of accomplishment
Chemistry and its importance (1 class)	Substance Properties Changes	• Heuristic conversation • Examination of properties and changes of substances from everyday life (sugar, carrot, potato, citric acid, water, baking powder, soapsuds, sodium bicarbonate, etc.) through demonstration experiments* and experiments for pupils' independent work**
Fundamental chemistry concepts (2 classes)	Physical changes Mixtures Separation of mixtures	• Demonstration experiments • Laboratory exercises (pupils' independent work)
	Chemical change Elements and compounds Law of conservation of mass	• Heuristic conversation • Demonstration experiments • Laboratory exercises
The structure of a substance (2 classes)	Atomic structure Valence Molecules of elements and compounds	• Heuristic conversation - didactic game with atom models (balloons of different sizes; balls for various sports games)* • Didactic game for pupils ("Atomic gangs-stable units")-constructing molecule models according to elements' valences**
	Chemical bond Covalent and ionic	• Laboratory exercise (perception of differences in ionic and covalent compounds and proving of cations of ionic compound by means of flame) • Didactic game ("Relatives are happy together")-constructing molecule and ionic pair models
Inorganic compounds (2 classes)	Oxidation Oxides Acids and bases	• Heuristic conversation • Demonstration experiments • Laboratory exercises
	Eletrolytic dissociation Salts	• Heuristic conversation • Demonstration experiments • Laboratory exercises

Table 1b. Introductory classes for teaching themes "Chemistry and its importance" and "The structure of a substance" – review of perceptions and conclusions

Teaching theme	Perceptions	Conclusions
Chemistry and its importance	*Separation of precipitate, gas, change of color ** States of substances, color, odor, dissolution, crystalline / amorphous structure	*Substances build up everything that surrounds us. Reagent can be anything around us. In their mutual contact, substances can react. **Two substances of equal state, color, crystalline (amorphous) structure, dissolubility need not react in the same way. Cause for substance's reactivity is in micro-plane but not in phenomenal.

Why do substances react differently when they are phenomenally equal?

The structure of a substance	*Atoms of elements differ in size. Nucleus contains two kinds of particles. Atoms of different elements contain different number of electrons in sphere. **Perception of model's characteristics (definite number of convex and concave parts) – association with valence – constructing a puzzle. Perception of ion charge (marked on models) – constructing models of ion pairs. Perception of differences in the behavior of covalent and ionic substances during heating. Ions of metals produce different colors of flame.	* Number of protons is equal to that of electrons. Atom is a neutral particle. The capacity of atoms to combine depends on electrons. ** It is possible to combine atoms of elements into stable units - a limiting factor in combining of atoms is valence. In ionic compounds the sum of negative and positive charge is equal. Substances X and Y are either ionic or covalent compound. Discovery of metal in ionic compound.

Due to the lack of space, it was impossible to give in detail how those classes were accomplished, students' perceptions and conclusions, so we have chosen only two themes: "Chemistry and its importance" and "The structure of a substance" (Tab. 1b). The reason for such a choice was that we wanted:

a) to show the modes whereby it was possible for students to get acquainted with chemical approach to nature study over spontaneous concepts they are familiar with in everyday life (theme I), and

b) to show various ways of getting acquainted with abstract concepts (atomic structure, valence, molecules of elements and compounds, chemical bond, covalent and ionic chemical bond) used for explaining properties and changes of substances.

In themes I and II students got acquainted with the subject matter of chemistry study – substances, their properties and changes they are liable to. Through their independent experimental work, students were able to perceive that different substances can be phenomenally equal (e.g. sugar powder and baking powder). In their reaction with another substance (acetic acid), however, these substances react differently. Thus, a problem situation has been developed that can be expressed by the question:

Why do substances react differently when they are phenomenally equal?

A partial answer to this question was provided within the framework of introductory class for theme II (The structure of a substance). The complexity of particles constituting substances (atoms, molecules and ions) was presented by means of heuristic conversation and atom models. To show that an atom is a complex particle, balloons were used for models – a small balloon (nucleus) placed in a big one (atom). Models of electrons, protons and neutrons were found in balloons. In this way, students were able to perceive how complex particle an atom is and that elements differ in the number of elementary particles. Balloon models were also employed to demonstrate how new units are created by combining atoms of the same or different elements.

When are units composed of atoms stable, and when they are not?

To perceive this phenomenon, atom models were available for students. The models were made in such a way that the number of concave and convex parts (puzzle) matched element valence. Combinations of those atom models resulted in a number of units – molecule models (13 molecule models). Stable units were obtained only by combining complementary atom models. 76% of students constructed correct molecule models. It should be pointed out that 28% of students tried to construct some other "unpredictable" molecule model. In constructing those molecule models, rules were observed of atom valences but not of "puzzle" principles. Thus, the concept of valence was introduced in a simple way. This didactic game made provisions for perceiving various possibilities of particle combining. Combining of particles is a basis for chemical reactions and a reason why a vast number of substances exist. The didactic game also resulted in the following question:

What makes possible for particles, associated in a unit due to valence, to stay together?

The concepts of chemical bond and types of chemical bond were introduced through heuristic conversation. By using experiments for independent work, students perceived differences in ionic and covalent compounds behavior. They applied their perceptions to characterizing substances X and Y as ionic and covalent compound. The conclusion about the type of chemical bond in a compound was additionally confirmed by placing the compound in flame and by identifying cation based on the color of flame, they had been acquainted with. In this way, students develop habit to gather arguments for decision–making.

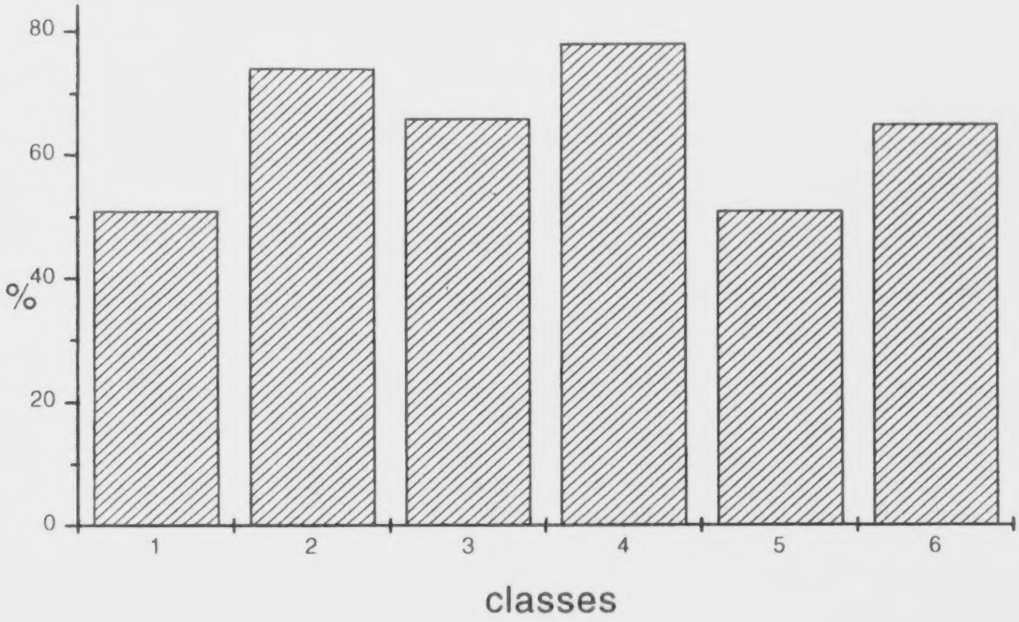

Fig. 1. Results in introductory classes for different teaching themes

The analysis of responses, recorded on work sheets, evidenced that high per cent of pupils (50–80%, Fig. 1) respond well to tasks posed, which related to:

- constructing of models of molecules
- perceptions during experiments performance,
- drawing of conclusions based on provided information items as well as on what has been perceived during demonstration experiments and those performed independently, and
- correlating the perceived properties and changes of substances with everyday life phenomena.

CONCLUSION

The results achieved in the present paper show that introductory classes of teaching themes, accomplished through heuristic conversation, didactic games, exploratory designed demonstration experiments and independent experiments provide a solid basis for acquiring concepts during teaching. They, no doubt, increase students' interest in certain spheres. As early as during introductory classes students begin to couple spontaneous and scientific concepts with concepts from everyday life.

The method of guided discovery, employed in acquainting students with basic scientific concepts during introductory classes, is a good introduction into problem learning. Students perceive that in the course of learning they are expected to continuously solve simpler and more complex practical and theoretical problems. The need for extending knowledge is ever present, so that perceived phenomena and changes could be explained as properly as possible. Students become aware that they need knowledge from different areas, which is of multiple importance: multidisciplinary approach to problem solving, learning through discussion and getting used to team working.

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Increasing the Effectivity of Science Education Through Interactive Tasks

Hana Čtrnáctová, Charles University of Prague
ctr@natur.cuni.cz

INTRODUCTION

In both primary and grammar schools, Science subjects are very important, both as a single Science subject or separate Biology, Physics and Chemistry. In the Czech Republic Science is taught as a stand-alone subject in the first stage of primary school (4 years) and as the subjects Biology, Physics and Chemistry in the second stage of primary school (4–3–2 years) and in grammar schools (2–3–4 years). Whereas Science is considered quite interesting by pupils, the separate subjects are taught mostly theoretically, so they are considered very demanding and difficult. The problems encountered while teaching these Science subjects are similar. They are connected with the objectives and syllabus content, methods and ways of teaching, verifying the results, increasing the pupils' motivation etc. Our main goal is to increase the education's effectivity. That is why we concentrate on one of the basic didactical ways to increase effectivity – interactive educational tasks.

One of the ways to make Science subjects easier to understand is to use interesting interactive educational tasks. That is why we have created a method for creating these tasks. If an educational task (or a set of these) is to be created, first we have to analyse the subject's curriculum, determine its goals, select basic concepts and determine their relations. Additionally we have to consider the extent of acquiring separate facts and the structure of activity which will allow them to do so at a given level.

Various questions, examples, exercises, tasks etc., overall called "educational tasks", are one of necessary parts of every lesson. This term is also often used in pedagogical, psychological and didactical literature, although a unified definition of educational task has never really been laid down. In accord with references we will define "educational task" as a demand on pupils to do some purposeful task aiming at a previously set goal. This goal requires both knowledge and action.

The educational tasks used in teaching usually come from two sources – either they are taken from textbooks and collections of exercises or they are conceived by the teachers themselves. Let's look at what types of educational tasks are the most frequently used in common practice.

We carried out an analysis of the tasks most widely used in Czech Science textbooks in basic and grammar schools. We found that the textbooks contain quite large numbers of tasks – more than 2.5 per lesson. However, the tasks are always put at the end of each theme block. They presuppose the pupil already knows the content of the block, and that they are only required to reproduce or explain it. The very setup of those tasks suggests they are very uniform in nature. They are usually simply pedantry and don't inspire students to solve them impulsively on their own. Only 4%–80% of tasks in these textbooks are in anyway different. Very often questions cover the curricula only formally, and usually they don't even respect different levels of acquiring knowledge and other activities.

Similar results were obtained by the analysis of educational tasks in other textbooks, exercise collections and tasks created by teachers.

METHODOLOGY

From both the results of pedagogically–psychological theory of educational processes and practice it is nevertheless clear that educational tasks should be a part of the whole educational process. They must be subject to the concept of educational theory and practice. These questions should be gathered into collections, and they should definitely be not monotonous, but, on the contrary, very varied.

When we create a collection of educational tasks, we should of course start with the analysis of curriculum from which the tasks will stem. The analysis of the curriculum is based on its contents and its arrangement within the theme as a whole. For expressing such an arrangement effectively we can use, for example, matrices or oriented graphs.

This method takes in an analysis of subject matter and its structure by matrix methods and creates concept maps which pupils can become familiar with. Thus acquiring each fact is connected with a set of activities. The structure and size of this set depends on the content and complexity of the fact itself and level of acquiring it. The structure of pupil's activity follows from Bloom's taxonomy and and contains levels of knowledge, applications, observations and experimentation and competences. The formal side of educational tasks is equally important as the content side. In accordance with debate as to which parts should be included in educational tasks we may perform an analysis of the form of text and the given solutions of the educational task.

The core of an educational task is usually described by one or more sentences. Usually, the question or instructions to solve the task are given verbally. All other parts of a task can be verbal too – motivating and complementary information, advice on the solution and expressing the answer.

Those parts, however, can also be given by a variety of nonverbal means. Their use in a task has a significant motivating effect because of their nonconventional and unusual approach, as the research confirmed (see part 4).

Our goal was to characterize the nonverbal means useful for the construction of educational tasks and expressing the presence of both verbal and nonverbal parts of educational tasks in a synoptic form, useful for analysing vast collection of tasks. After studying various ways of processing large data files, we determined the table form to be the best for our purpose. Every row of the table corresponds to one educational task. The presence of various verbal and nonverbal parts of a task are marked in the columns. The parts of a task are arranged in the order of increasing motivational levels.

Symbol	**Meaning**	**Marking**
V	verbal part, i.e. text which contains advice or a question	+
I	additional information – either necessary data for answering the question or motivational text	+, ++
T	table – the legend contains two groups of elements, and their relation is explained in the table	+, ++
S	scheme – the elements of scheme are given by words or formulas and they are connected by lines or arrows	+, ++
G	graph – relation of two or more elements, where the elements – nodes of graph are only given by symbols and they are connected by lines – edges	+, ++
M	model or a picture of a model	+, ++
R	reality or a picture of a reality – illustration, photography etc.	+, ++

These 7 forms inform us about the educational task.

The presence of a form in task is marked by +. If it is also used for motivation, it is marked by ++.

Here is an example of a table for a group of 6 educational tasks.

Task	V	I	T	S	G	M	R
I-1-1	+						
I-1-2	+	++					
I-1-3	+						
I-1-4	+						
I-1-5	+	++					
I-1-6	+						

All these tasks are just verbal, but tasks 2–5 also use some motivational information.

Task	V	I	T	S	G	M	R
I-1-1	+	++					
I-1-2	+		++				
I-1-3	+			+			
I-1-4	+		+			+	
I-1-5	+	+					
I-1-6	+			+			++

These tasks use various nonverbal means.

Symbol	Meaning	Marking
P	the task does not contain any advice for a solution	
P	the task does contain some advice for solution	+

Task	V	I	T	S	G	M	R	P
I-10-1	+	+					++	+
I-10-2	+	+	+					
I-10-3	+	++		+				+
I-10-4	+					++		+
I-10-5	+	+		++				
I-10-6	+		+					+

These tasks are very various – there are tasks with many nonverbal parts.

Tasks 1, 3, 4 and 6 contain information about the method of solving the problem.

Therefore, if we want to create a collection of various educational tasks, the formulation of the task must contain as many different verbal and nonverbal parts of both assignment and solution as possible. The overview of the character of such a file can be obtained in the form of a table containing all 8 entries as we see.

APPLICATION

These theoretical results were gradually confirmed in practice. We created six collections of educational tasks for curricula of general, inorganic and organic chemistry and biochemistry in primary and secondary schools in the form of workbooks containing more than 800 educational tasks.

We now show an example of determining the contents and degree of acquiring of knowledge in separate tasks for the *Composition of Atom* theme.

Theme: **Composition of Atom**

The level of acquiring: **Understanding and application of knowledge**

In the basic school, the pupils have to have a basic idea about the elementary building block of matter – atoms; they have to know the make up of an atom and understand it. They should be able to apply knowledge about the composition of atoms and determine a composition for a given atom. The activity leading to the final goal (i.e. understanding the term at the required level) has this structure:

Final Goal To use the knowledge about the composition of atom in solving given tasks.	**Activity** To determine the composition of a given chemical element's atom.
Intermediate Goal 3 To understand the knowledge about the composition of an atom.	**Operation 3** To explain the composition of an atom.
Intermediate Goal 2 To acquire the knowledge about the composition of an atom.	**Operation 2** To remember the knowledge about the composition of an atom.
Intermediate Goal 1 To get the idea of atom as a basic building block of the matter.	**Operation 1** To imagine matter being built up of many small particles – atoms.

Therefore, for the acquiring of the term at the required level, at least four educational tasks need to be solved: task 1 (Intermediate goal 1 – Operation 1), task 2 (Intermediate Goal 2 – Operation 2), task 3 (Intermediate Goal 3 – Operation 3), task 4 (Final Goal – Activity).

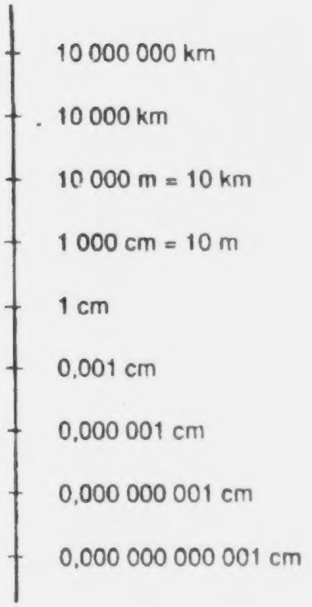
Task 1: The matter is made up of very small particles – atoms. You can get the idea about atoms' tiny size by completing the graph for picture 1. Assign letters A to I to the values in graph.

A – The diameter of Earth
B – Red blood cell
C – The highest mountain on Earth
D – Macromolecule
E – The distance Earth–Sun
F – Atom
G – Three–storey house
H – The diameter of Aspirin tablet
I – The atom nucleus

Task 2: Fill in the missing words:

An atom is made up of .... and ....
The electronic shell is made up of ....
The nucleus is made of .... and ....

br. 8


10 000 000 km
10 000 km
10 000 m = 10 km
1 000 cm = 10 m
1 cm
0,001 cm
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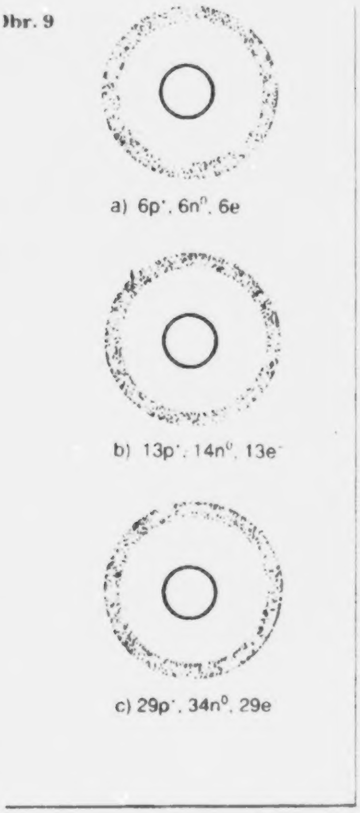
0,000 000 000 001 cm

Picture 1

br. 9


a) 6p⁺, 6n⁰, 6e
b) 13p⁺, 14n⁰, 13e⁻
c) 29p⁺, 34n⁰, 29e

Picture 2

Task 3: In the picture 2 you can see three atoms. According to the descriptions a} to c} fill in the number of protons, electrons and neutrons in those atoms.

a) $6p^+$, $6n^0$, $6e^-$ b) $13p^+$, $14n^0$, $13e^-$ c) $29p^+$, $34n^0$, $29e^-$

Task 4: Fill in the missing data in the table:

Z - proton number	A - Nuclear number	Number of electrons	Number of protons	Number of neutrons	Name of element	Symbol of element
	20			10		
12	26					
		16		16		
35	79					
			47	60		
82				126		

EVALUATION

For confirming our results we used several methods: Objective tests and comparative analysis and results of education with and without using the use of tasks, as well as subjective methods – anonymous surveys amongst pupils.

110 pupils who used the workbook in their chemistry lessons participated in the survey. They were asked two questions:

1. Explain where the workbook helps you and what are its advantages.
2. Explain where the workbook does not suit you and what are its disadvantages.

The very fact that number of advantages given were twice as large than the number of disadvantages, tells how popular these workbooks are.

The pupils themselves evaluated workbooks as textbooks which are nice to work with (33%), full of interesting information, pictures, tables, graphs, schemes and crosswords (73%), comprehensive, synoptic and easy to learn (49%). Incomplete pictures, tables, graphs and schemes assist pupils to solve a task.

164 pupils of both control and experimental classes participated in the verification of the level of acquired curriculum with the use of didactic tests. In the experimental classes, workbooks were used during lessons along with textbooks. Pupils were solving the tasks from workbook now only while (studying?) the curriculum, as usual, but also during the acquisition of new facts. In the comparative classes pupils only worked with the textbook and solved only tasks contained in it. To evaluate, both qualitatively and quantitatively, differences in the level of acquisition, we created a didactic test, made pupils in all classes do it and statistically processed the results. The test contained 20 questions about quite difficult theoretical matters concerning the structure of substances. The results of the tests confirmed that with the use of the collection of educational tasks, more pupils acquired the knowledge than did those who were not using the educational tasks.

CONCLUSION

In the conclusion, we can say that results from creating this collection and its verification in practice, confirm the adequacy and usability of our theoretical process of creating the tasks. Both the ways of determining the content of various tasks and their (collecting together?) with the accent on the degree of acquisition of knowledge of the curriculum and methods for constructing these tasks with the accent on their (formalisation?) seem sound.

Through application of these ways and criteria within specific parts of the educational process, we can create sets of educational tasks which can increase the interest in Science subjects and acquisition of knowledge at a given level by more pupils then solely with the standard educational methods pertaining previously.

The current method was applied to writing six workbooks (they include more then

800 varied tasks) for the subject of Chemistry in our department of Chemical Education, both for primary schools and grammar schools. The learning by means of chemical educational tasks doesn't make only for knowledge acquisition but also for competence in students' education. They are widely used now in both primary and grammar schools in Czech Republic. The tasks are interesting for pupils. They help them to understand the subject matter and they ensure its better grasp. Research, using performance tests, was carried out with pupils who used, or didn't use, the method of interactive tasks. Statistical results show a significant increase in effectivity of education when using this interactive educational method.

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ParCIS: Aiming for Scientific Literacy Through Self-Regulated Learning with the Internet

Wolfgang Gräber, Thorsten Erdmann, and Volker Schlieker
Institute for Science Education (IPN) at the University of Kiel, Germany
wgraeber@ipn.uni-kiel.de

When you ask adults what their favourite subject was in school, they almost never answer "chemistry". Most of them will only remember formulas and equations which they never really understood. The same is true for calculations and reports which ruined even that little fun they had doing the few experiments they were to do. Another thing most adults have in common is the feeling that what they learned in chemistry class was not important for later life, unless they ended up working in a chemistry-related profession.

When such statements are compared with those from students who have not had any chemistry lessons yet, a deep schism between the two becomes obvious. Ten to twelve year-old pupils generally look forward to having chemistry lessons and expect a lot from them. They hardly can await the first chemistry period. But pupils' originally positive attitude towards science subjects changes significantly in the upper grades (9th and 10th), especially in chemistry and physics. Many English-speaking authors have commented on this (Schibeci 1984). The same is true for German-speaking authors. Such a negative attitude towards a subject leads to a lack of interest and, when the subjects can be selected as in the course system of the upper secondary level of the German GYMNASIUM or the British sixth form they are likely to drop the subject or course (Schmied 1982).

The task of compulsory schools is to educate students to be mature responsible citizens. Science education contributes to fulfil this task by imparting knowledge and skills as well as fostering the development of attitudes, interests, and values. Interest, therefore, has a double function: On the one hand, interest is a pre-requisite for meaningful learning (see also Rennie & Punch 1991; Nenniger 1992; Schiefele U. et al. 1992; Voss & Schauble 1992); recent empirical findings underscore this assumption by recognizing that learning guided by interest leads to a more complex and flexible structure of knowledge than extrinsically motivated learning processes (Biggs & Collis 1982). On the other hand interest represents the goal of teaching to guarantee a life-long open-mindedness (see Schiefele, H. et al. 1979).

Because of this double function, importance should be attached to the construct of interest within research of science education. For about twenty years now, the IPN has been doing research on "interest" or "subject–related motivation" especially in physics (see Lehrke et al. 1985). Between 1984 and 1989 a comprehensive longitudinal study (Häußler 1987, Hoffmann & Häußler 1995) was carried out in connection with a cross–sectional one on this specific topic. In 1988 we began to plan a study on research interest in chemistry (Gräber 1998) similar to that in physics so that the knowledge and experiences gained from the given long–standing research could be referred to. Besides, the chemistry–related study of interest was founded on an extensive inquiry of relevant literature. We intended to find out how the decrease of interest and the tendency to drop the subject Chemistry has been explained by international researchers so far. We found that even the daily press has called attention to this topic: For example, the British newspaper "The Observer" (Noble 1993) pointed out that pupils turn their backs on chemistry because of its negative image. "It is that, compared with 30 years ago, the downside to science and technology is more fully recognized. Technological disasters such as Chernobyl and ethical problems arising from advances in genetics have weighed heavily with those who imagine that life was once relatively problem–free." The study of Heilbronner and Wyss (1984) demonstrates it in an impressive way: 11 to 15–year old students at various "Gymnasiums" and "Realschulen" were asked to portray their imagination of chemistry in a drawing. Two thirds of the drawings predominantly displayed the negative aspects such as the pollution and destruction of the environment or animal experiments.

Besides this *poor image of science and technology*, I would like to point out some common associations with chemistry lessons:

- Many male and even more female students complain that chemistry is *too abstract, thus cannot be related to their environment*, and quote this as reason for dropping chemistry. With regard to this deficiency, Stork (1984) says: Chemistry lessons mainly focus on problems which are related to the interconnection of chemistry–specific concepts. As students see it, chemistry is limited to the proceedings only within the lesson, while the knowledge gained from it cannot be utilized for mastering off–school life situations."
- Science lessons are very often dominated by the teacher. Instead of organizing a student oriented stimulating learning environment teachers tend to transfer knowledge to passive students by lecturing. In this context the *teacher's personality* gains much importance. Mead and Métraux (1973) studied many thousands of teachers and their characterization can be summarized as follows: "Scientists tend to transfer their discipline's abstracting methods to everyday life and the classroom instead of enlivening the material with their personality."
- Another reason for the unpopularity of chemistry lessons comes with the *subjects' difficulty*. Most of the topics in chemistry are abstract in nature, meaning working with theories and models. Such work requires thinking at a formal–operational level. However, various studies show that most of the students at the age level in question

have not reached this level of thinking. We have carried out an empirical study using a Piaget test from A. Lawson on 354 students at 10th grade at German "Gymnasiums" and found that only one quarter of these 15– to 16–year olds were able to think in a formal–operational manner (Gräber & Stork 1984). Miller (1997) has been involved in measuring the scientific literacy of the American public for many years, and has extracted two factors from the data that were produced by the National Science Foundation: the vocabulary dimension, and the understanding of the nature of scientific inquiry. His findings underline the difficulty of learning science: Only 7% of the people investigated in 1995 scored high on both factors, and can thus be considered scientifically literate.

All in all, Seelig (1968) comprises his investigations of the popularity of chemistry and physics courses: "Physics and chemistry lessons give pupils the impression of being too theoretical, too dry, and too difficult." Many other studies have confirmed this negative view on science teaching and learning world wide (e. g. Simpson & Oliver 1990, Sjöberg 1997, Miller 1997, TIMSS III). Attitudes toward science and science teaching are negative, interest in the subject is declining with progressing school time and the cognitive learning outcome is very poor. Even the small amount of facts and concepts which has been learned and kept in mind can't be applied to everyday life situations by the majority of students.

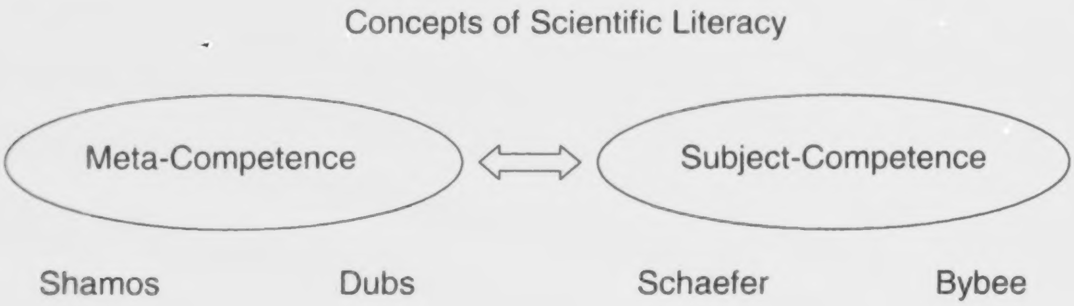
These disappointing observations raise the question of whether we even treat the right topics in school and follow adequate goals. Which criteria are important for selecting goals and content? P. Häußler listed the following five points in his presentation at the IPN–Seminar on scientific literacy: the academic disciplines, life situations, recommendations of experts, interests of students and concepts of general literacy. Each of these criteria has its own significance, while the last one, a concept of general literacy, which of course also includes parts of the others, seems us to be the most important one and leads us to scientific literacy.

Scientific Literacy: The Goal of Science Teaching and Learning at School

We organized two international symposia on scientific literacy at the IPN, which helped to structure the topic and formed the base of further research and development. While the first one (Gräber & Bolte 1996) focused on the theoretical background, the second one (Erdmann, Gräber, Nentwig 1999) intended to bridge the gap between theory and practice.

The 2nd International IPN Symposium on Scientific Literacy (Kiel, October 7–11, 1998) (http://www.ipn.uni–kiel.de/projekte/a4_5/sympos2/allgem2.htm) was part of a long–range multi–national initiative to promote the development of scientifically literate citizens. It built upon and extended the outcomes of the first symposium and involved some past participants as organizers. Specifically, the purpose was to apply our conceptual understanding of scientific literacy to the concrete world of science teaching and learning. The symposium also strived to bridge the gap between theory and practice by having academics, university professors and researchers, develop and teach lessons to pupils. Four keynote speakers (Rodger W. Bybee, Rolf Dubs, Gerhard Schaefer, Morris Shamos) described the theoretical background and tried to bridge the gap to practice, while 12 video contributors presented real science lessons. These video contributors from different countries all over the world showed tape recorded science lessons of how they try to promote the development of aspects of scientific literacy. Each video presentation was complemented by a discussant who was expected to enrich the discussion with his own view on the subject.

Our keynote speakers' definitions of scientific literacy could be placed (roughly taken) along a continuum with the poles of focussing more on subject competencies or on higher meta–competencies.



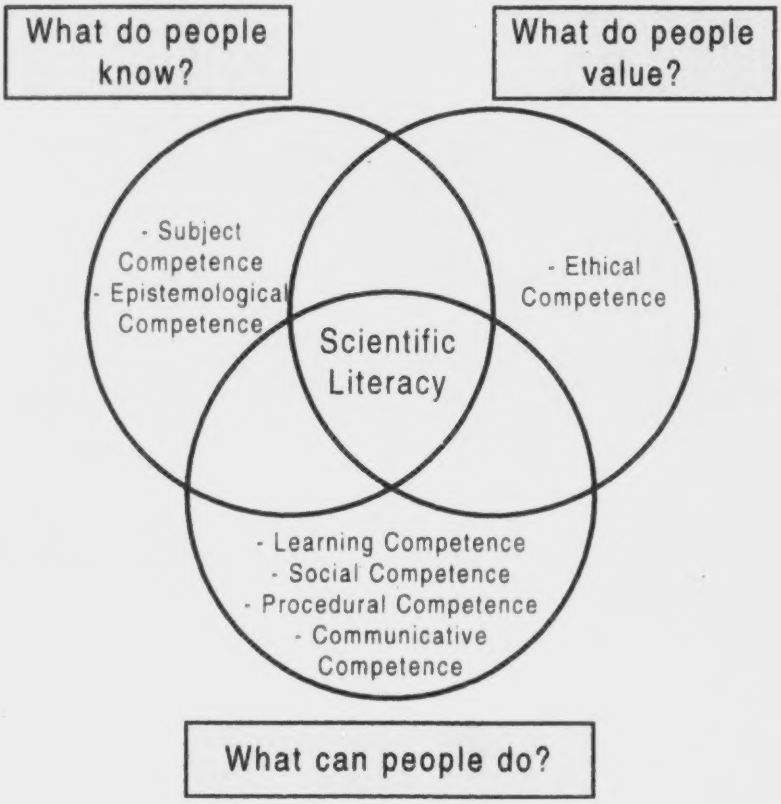
Rodger Bybee has proposed a comprehensive hierarchical model, which forms the base of the National Science Education Standards of the USA, which is still very much driven by the science's discipline (by of course considering life contexts and cross–curricular competencies).

Gerhard Schaefer tries to mediate between the two extreme positions. His literacy model is not based on a mosaic–like summary of academic defined subjects as propagated by many scientists, but there are general competences which constitute the construct general literacy or life competence. A central position is taken by subject competence through which the different subjects contribute to develop the other competences.

According to Rolf Dubs the general aim of teaching science should not be to reproduce the university disciplines at the general school level but to be oriented towards societal requirements, to learn how to deal with social issues and to make rationally founded decisions.

Morris Shamos (1995) refers to the negative outcome of science teaching and has suggested that the science education community has deceived itself into thinking that a definition of scientific literacy which includes both wide and deep content knowledge and process competence is possible. He proposes a more realistic definition which challenges science educators to help students become competent consumers of science and to trust the real issues to science experts.

Summarizing the various proposed definitions and models and taking into account the skepticism of Shamos and others, we would like to suggest a competency based model of scientific literacy, going back to Schaefer's request for "life–competence" as a goal for education in school. In this approach the question is not the causal "why" do we teach science to children but rather the final "what for", and consequently the answers are not "because our societies need a scientifically literate workforce" (or other justifications). The answer is "for the individual to cope with our complex world." Competencies are needed for that task, and some specific competencies can be acquired in the science domain better than in others. Science teaching traditionally concentrates on the knowledge aspect, adding perhaps a few of the procedural skills, but usually neglecting the other competencies. The view proposed here may help to reconsider the balance between the various competencies and to reflect, what specific contribution science education can make.


What do people know?
What do people value?
- Subject Competence
- Epistemological Competence
- Ethical Competence
Scientific Literacy
- Learning Competence
- Social Competence
- Procedural Competence
- Communicative Competence
What can people do?

The Gap between Theory and Practice

An analysis of science–classroom videos at the 2nd International IPN–Symposium on Scientific Literacy shows that science teaching can be described in three dimensions. Each dimension can be characterized by two extremes on a scale:

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teacher centred – student oriented

It is either the teacher governing the classroom activities, steering the students' learning processes, and dominating the communication process or the students taking responsibility for their own progress, initiating their learning processes in a more or less autonomous way.

teaching facts – teaching processes

The teaching/learning activities aim either at science facts, laws, and formula or at the acquisition of problem solving strategies and skills of processing information and interpreting data.

discipline oriented – daily–life oriented

The aim of the lessons can be to either delineate the structure of a scientific discipline and to reproduce research findings on a reduced level or to provide means to understand daily–life phenomena, including their social, technological and economic implications.

Traditionally, science teaching is lopsided towards the left side of each of these scales. Teachers tend to dominate the teaching/learning process with fact oriented lesson contents and the aim to reproduce (at least part of) the structure of their scientific discipline in the heads of their students. The results of these efforts have been disillusioning world wide.

A look at the list of competencies which, each with their own weight, constitute "scientific literacy", makes it evident that such science teaching must fall short of reaching the goal. We are not suggesting that all engines should be turned on reverse and that the opposite approach – student autonomy, acquisition of process skills, daily–life orientation – is the recipe for successful science teaching. Obviously often enough students do not take responsibility for their own learning processes, facts are necessary for applying skills, and daily–life phenomena are often too complex to understand with regular students' limited knowledge.

However, to reach some extent of scientific literacy for all students, more of these ingredients must be introduced to science classrooms, and in order to do that, teachers must be able to act expertly on both sides of the scale in all three dimensions.

Self–regulated learning

If we take scientific literacy serious as a goal of science education, and if we want science classes to contribute to the general education of emancipated citizens, we must re–balance the orientation of our teaching. Careful guidance of children towards self–regulated learning must have priority. This can be explained with terms such as self–determination, self–responsibility and self–activity.

Self–determination as a basis of all emancipative efforts makes the learner independent of a teaching person. Self–responsibility for one's own learning process is the prerequisite for life-long learning, which depends on self-activity, if it is meant to be fruitful and lasting.

ParCIS: Partnership between Chemical Industry and Schools

The new electronic media are ideal vehicles to support self-regulated learning. We try to use this chance by starting a new project ParCIS (Partnership between Chemical Industry and Schools) in cooperation with schools and industry aiming for developing competences for self-regulated learning and media-competence.

The most important goal of ParCIS is to promote self-regulated learning and media-competence. In addition to ordinary classes, the students will work autonomously in small groups on open questions. They will gather information from various sources (e.g. textbooks, encyclopaedias, newspapers), but in particular from the internet, where information is supplied by several educational services, textbook publishers, schools, universities as well as industry. All these possibilities are to be used, but the focus of this project will be on those websites created by chemical enterprises in the neighbourhood of the schools

Most of the information nowadays found in the internet is – although it might be relevant in terms of the curriculum – either incomprehensible or not meaningful to the students, and cannot be used in the classroom. The chemical enterprises participating in this project will help to close this gap. They will present general chemical content as well as specific information from their field in a way that is meaningful to students. These websites will be designed and developed by a research group consisting of industry representatives, researchers and teachers.

We are going to develop and evaluate different exemplary lesson guides. Because of our first industrial partner, the international chemical concern Bayer, we will focus on plastics and dyes; these are the main fields of expertise of Bayer in Schleswig-Holstein (Germany). The traditional way of teaching dyes in German schools is to start with theoretical foundations on the structure of dye molecules, chromophoric π-electrons system, and coloured light and electromagnetic waves. With this background the different classes of dyes will be treated one after the other, e.g. polymethines, triphenylmethanes, azodyes, phthalocyanines a.s.o. This course will be finished by the discussion of applications of dyes in chemistry and everyday life situations. The whole sequence is structured and dominated by the teacher, enlivened by some groupwork labs.

Our intention, in promoting self-regulated learning competences, is to teach in a more student oriented way adapted to the cognitive apprenticeship model (Collins, Brown & Newman 1989) with the following steps: Modelling, coaching, scaffolding, fading, articulation, reflection, exploration.

The whole sequence is taught in a way that is application led similar to the central way of STS teaching. The first step (modelling) is the introduction of theory and practice of dyes through a teacher structured example from everyday life (e.g. hair dying).

The teacher shows as an expert how to work on such a topic, which questions to ask, how to plan the project, how to find, handle and evaluate adequate information (particularly from the internet) and how to present and discuss the results. Although the teacher controls the procedure the students are not passive consumers but join him/ her actively asking questions, planning, experimenting or thinking.

Following this introduction the students work in groups on own mini-projects of dyes' application. The teacher's main task is to coach and scaffold the self-regulated processes, with a gradually fading of support. Articulation and reflection of the processes and their results will be completed by presentations of the groupwork through posters, portfolios, html-documents, PowerPoint-presentations or the like.

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Operationalising Scientific and Technological Literacy – A New Approach to Science Teaching

Jack Holbrook, *icase@logos.cy.net*
Secretary, International Council for Associations
in Science Education (ICASE)

Key words – scientific and technological literacy, relevant science education

THE NEED FOR RELEVANCE IN SCIENCE TEACHING

Although school science tries to develop conceptual understanding in students and an appreciation of the way scientists do things, its relevance to society is suspect (Pak, 1997; Yager, 1996). The understanding and scientific method tends not to be relevance for functionality in our lives i.e. relevant to the home, the environment, future employment and most definitely for future changes and developments within the society. Rather the understanding tends to be geared to internal concepts within the subject itself. Concepts such as pressure or chemical bonding are almost universally chapter headings in science courses, yet in daily life, inflating car tyres correctly to minimise accidents, improving the quality of the air for our health, are much more relevant starting points.

To a large extent science education in schools is not relevant (Champagne et al, 1985; Lederman, 1992; Novick and Nussbaum, 1981; Osborne and Freyberg, 1986; Ryan and Aikenhead, 1992). Generalising, science curricula put the subject first, and the application a poor second. They forget that relevancy is in the processes and products we utilise in society, and only afterwards in the understanding, should we wish to utilise scientific principles in solving a problem or making a decision. Thus, in terms of relevant conceptual learning, it would seem that current curriculum approaches are suspect. It would seem we need to find ways to initiate teaching from societal situations and then develop the conceptual learning that allows students to appreciate the relevance of the science (Holbrook, 1994).

It is important to take into account that relevancy goes beyond the acquiring of knowledge or conceptual understanding. It encompasses also attitudes towards the learning of science and to the making of decisions geared to societal concerns e.g. ensuring sustainable development and the development of social values. These are areas that are rarely considered in many science courses. Science curricula tend to forget that education is the rationale for schooling and that science education is an integral, not a separate, part of this.

The role of science education must be nothing less than playing its part in enabling students to acquire the goals of education. However it would seem that teachers are failing to recognise this target. And this is largely because school science curricula, examinations in science subjects and, of course, the textbooks have failed to recognise adequately these goals. It is time for change.

EDUCATION FOR SCIENTIFIC AND TECHNOLOGICAL LITERACY (STL)

Taking all the attributes and for want of a better term, the relevant science education for which we strive can be expressed as 'Scientific and Technological Literacy' (STL) (Holbrook, 1997).

STL education sets about preparing citizens for life within the society, both for today and the future. By preparing for life within the society, it is intended that students acquire skills and attitudes so as to be able to:

(i) undertake further education of choice and be empowered to secure rewarding employment;

(ii) function in a positive social manner within society;

(iii) adapt to, and be prepared for, change in the future;

(iv) play a responsible role as a citizen within the society.

The goal of science education can surely be nothing less than to aspire to STL. This means it is a much more human, caring approach than an academic pursuit, even though it still leads to an acquisition of scientific concepts. An important goal of science teaching is to meet the challenge of operationalising STL.

But how? Obviously it would not be fair to claim any one approach can be the sole response. Changing public opinion by attempting to combat ignorance of the role of science education is certainly a factor. The need here is to popularise science. But the factor put forward here, which has not received the attention it deserves, is perhaps the major component for the lack of change in school teaching of science subjects. *That factor is the vision of science teaching by teachers themselves.*

Perhaps more than in any other subject area, science teachers perceive their task as teaching the subject matter (Aikenhead, 1997). They see their task as imparting knowledge and understanding of the principles that underlie this knowledge (Romberg, 1985). The feeling is so strong that 'completing the syllabus', as exemplified in the textbook, is a common science teacher cry. Experimental investigations are given a low priority, especially if the external examination places little weighting in this area. Assisting students to develop skills of problem solving is not taken seriously, unless this simply means tackling a variety of numerical problems. Time is certainly not to be set aside for planning an investigation and then carrying it out, or for decision making situations where the answer is not clear cut and a multitude of factors can influence the decision, such as economic, social, environmental, political, or ethical considerations.

AVOIDING CHANGE

Evidence suggests that teachers try to avoid change, especially change that demands their expertise may be undermined (Aikenhead, 1997). Science teachers have not had to deal with the development of societally useful problem solving or decision making skills in the past. Teachers have not had to deal with the development of the student as a member of society, or the development of societal skills (so as to be a responsible member of society) during science lessons in the past. Thus science teachers are uneasy about bringing ethical or social values into the science classroom, even when these have great relevance to the society (Gaskell, 1982).

SO WHAT CAN BE DONE ? HOW TO OPERATIONALISE STL ?

First and foremost is the need to change the teacher's perception of what science teaching is about. *Science teachers need to be guided to teach students (teachers must recognise that it is the students they teach, not simply a body of knowledge).* And this means playing their part in meeting the educational goals put forward for schooling. Science teachers must realise that education is not solely about concepts and content, but requires attention to personal and societal skills, to ethical considerations and above all, it requires attention to the affective domain. Science education must be seen as part of education.

The task before us is to get science teachers to change for a new image of science education – STL for All. This image cares about the students as individuals. Teachers develop new approaches to teaching that encompass a greater degree of student centred teaching (Gunstone, 1997); they give more attention to relevance to the society, to values education and above all, science teachers give attention to the development of personal qualities and positive attitudes.

Without doubt, contemplating change means teachers need in–service support. But this in–service provision needs very careful consideration to address the real needs of teachers (Cho, 1997). Telling teachers to change is not likely to help the situation. They need to be shown how, and to appreciate why, this is the manner in which to change. Teacher trainers must be convinced of the need to change and for change to actually occur, teachers need to be convinced how the change can be successfully implemented.

CONVINCING TEACHERS TO EMBRACE CHANGE

Two factors are considered of special significance:

(a) One aspect is to provide research evidence showing change can lead to substantial gains by students and, very importantly, that students do not suffer in their ability to pursue science courses at a higher level (Boyer, 1983; Byrne and Johnstone, 1988; Goodlad, 1984).

What research evidence there is, shows that pursuing higher order thinking skills is more rewarding for students than factual memory exercises, even though they cover less factual material. Research evidence shows that positive attitudes are enhanced by greater societal relevance and by more student involvement. Research evidence shows that student positive attitudes leads to greater academic gains. And, provided the examination, or the student assessment indicator, are well prepared, the students achieve higher when showing a more positive attitude towards the subject and are able to use a range of educational skills (Kellerman, 1993; Liu, 1997; McCormas, 1996; Weiss, 1993).

(b) A second factor is providing suitable in–service courses (Yager, Hiddayat and Penick, 1988). One approach that shows signs of success is to encourage teachers to reflect on the changing needs of science education and then, with this in mind, to develop supplementary teaching materials that meet this need. Teacher workshops which pay great attention to the philosophy of STL, have been developed by ICASE (Holbrook and Rannikmae, 1997) and materials deriving from these workshops are beginning to appear. Giving teachers ownership of this philosophy, by teachers creating supplementary teaching materials which meet STL criteria, becomes the main focus of the workshops, although the real goal is to give teacher ownership of the STL philosophy being expounded.

CRITERIA FOR EXEMPLARY STL MATERIALS

The criteria being suggested for the creation of exemplary STL supplementary teaching materials (Holbrook, 1997; Holbrook and Rannikmae, 1997) are:

a) PROMOTES STUDENT ACHIEVEMENT IN A RANGE OF EDUCATION GOALS

– a wide range of education goals are stipulated and form the major focus of the material i.e. students are participating in the process of educational learning, appropriate for the goals of the country and their intellectual development. These goals not only relate to science concepts and scientific method, but also include social values and the development of personal skills.

b) STARTS FROM A CONCERN OR ISSUE IN SOCIETY

– the material is societally related and draws on an issue or concern within the society. Students are familiar with the situation, can thus appreciate its relevance and are able to build on constructs already formed. The material is directly relevant in the eyes of the students. Creating material on pressure, or bonding or photosynthesis is not, it is suggested, directly relevant because the relevance is not overt. Creating materials on the correct inflation of car tyres for safety, the need for moisturising the skin for healthy living, or the issue of the Amazon rain forests for global warming is relevant. The relevance is clear even though the conceptual science may not have changed.

c) INVOLVES DEMANDING (HIGHER ORDER) THINKING SKILLS

– undertaking the activity is an appropriate learning exercise for the learner i.e. it provides an intellectual challenge at an appropriate level for the students. It utilizes constructivist principles – moving from information and understanding already in the possession of students, to the new learning situation. It involves analytical or judgemental thought.

d) STUDENT PARTICIPATORY

– the teaching approach and activities are designed to be student participatory i.e. the scripts involve the students, either individually or in groups, for a considerable amount (>60%) of the teaching time. This does not necessary mean the teaching material is experimentally orientated (although this is important), but it does mean attention is paid to the incorporation of a variety of teaching approaches through which students can participate.

e) INCLUDES A COMMUNICATION SKILL COMPONENT

– due consideration is given to enhancing a wide range of communication skills appropriate for the dissemination of scientific ideas and social values. This will involve oral (group discussion, debate, role playing), graphical, tabular, symbolic, pictorial as well as written forms.

f) RELATES TO SCIENCE EDUCATION

– whilst the material links science teaching to social science, particularly by the scenario from which the material is developed, the teaching still retains science concept acquisition and attention to the development of scientific processes. The material is definitely education through science, not a social science add–on to a previously taught academic science component (thus differing from SATIS materials).

g) INCLUDES A COMPREHENSIVE TEACHER'S GUIDE

– as problems, issues and concerns coming from society are often interdisciplinary in character, with the science ideas unfamiliar to the teacher, full explanations are needed to help teachers make use of the materials in a meaningful and interesting manner

– the teachers guide also needs to highlight the link between activities put forward and the outcomes expected of the teaching in terms of educational objectives

– the teacher's guide needs to detail a suggested teaching strategy by which the student centred approach is exemplified.

HOW SHOULD TEACHERS ACQUIRE THIS DIRECTION AND UTILISE STL MATERIALS ?

The simple answer is for teachers to participate in STL in–service courses, be introduced to the criteria and then to try to create their own teaching materials. If teachers can do this (and it is by no means an easy task) and the newly created material reflects the new direction of teaching, then by using this they will be operationalising STL in the classroom (Rannikmae, 1997). The new material will take into account automatically the widening vision of science education.

If teachers choose not create the material themselves, but use existing material, they still need to ensure they are conversant with the new STL vision of education. This means they need to accept the idea that science education starts from a social concern or issue before progressing to the science method and scientific concepts. And that science education involves social values and personal development as well as science conceptual ideas.

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STL Teaching – Immediate and Longitudinal Influence on Students' Learning.

Miia Rannikmäe, *miia@lai.ut.ee*, University of Tartu, Estonia

ABSTRACT

This paper illustrates the effectiveness of two models of STL teaching in the classroom. The teaching of scientific and technological literacy for all (STL) involves increasing the relevance of teaching through relating it to local issues or concerns and incorporating values education. STL supplementary teaching materials were defined as materials which were social issue based, student centred, decision–making, and/or problem–solving units, within curriculum topics (Holbrook & Rannikmäe, 1997).

Altogether, forty five teachers and 1163 students were involved in different studies over the period 1997–2001. It was found that the major factor illustrating teachers ownership of teaching STL was their involvement in the process of creating supplementary teaching materials, described through the longitudinal classroom observation study.

INTRODUCTION

Promoting STL among students has become a major target of science teaching over the last decade. Different countries have been approaching this process from their own viewpoint, but it has been obvious that teaching facts, or even guiding students to acquire isolated scientific concepts, was not enough. The focus of school programmes has been to move beyond acquisition of knowledge and focus more on the development of learning skills, values and ideas. The target of science teaching has been to help students gain the total range of educational objectives put forward for schooling at a certain age level. Bybee (1993) divided these educational objectives and by modifying his ideas slightly four major areas can be put forward – empirical knowledge, scientific method, personal development of students including career awareness and social development, or achieving the aspiration of society.

Achieving these objectives is not easy task for teachers. Research has shown, that there are big gaps between students' wishes and traditional teaching, heavily influenced by teachers' attitudes (Rannikmäe, 1998, Hofstein & Malmok, 2000), lack of teaching skills to assess against wider goals of science education and the need for in–service guidance for better understanding about the socially oriented goals for teaching science (Holbrook, 1999).

Teachers are afraid of change – teacher try to avoid change especially change where their expertise may be undermined) and therefore they must be guided through the various teaching stages (Aikenhead, 1997). Teachers in research projects had concerns about doing something different in the classroom (Bell & Gilbert, 1994). These concerns include fear of losing control in the classroom, covering the curriculum, meeting assessment requirements, etc. At the same time, we know that teachers are excellent learners who are interested in enhancing their teaching methods. But after attending in–service courses they still feel unable to use the new teaching activities, curriculum materials or content knowledge to improve the learning of their students (Bell, 1998).

Teacher change is linked with teacher beliefs. Previous studies have showed that perceptions and beliefs of teachers are strongly connected with their practice and behaviour. Teachers and their beliefs play a major role in science education reform, since teacher beliefs lead to actions, and these actions ultimately impact on students (Lumpe et.al, 1998). These beliefs and perceptions are part of teachers' professional ownership of, and greater control over, their own work. Teachers assimilate new content better and use varied teaching methods when they are actively participating in the development of teaching or evaluation methods (Sabar & Shafriri, 1982), or when they cooperate in the framework of a teacher team in planning their work (Oakland, 1995). So far there is little literature, which describes models, and case studies that can help in building an educationally effective framework for the professional development of teachers.

Based on the above issues, the goal for this study was to determine criteria for the evaluation of the effectiveness of STL teaching among students and to find factors, which most strongly influence teachers skills to promote STL among students. For teaching STL (Holbrook, 1998), it is obvious that teachers should be equipped with new types of teaching materials (Holbrook & Rannikmäe, 1997) that will motivate students' learning and take school science away from purely subject oriented textbook based teaching.

RESEARCH DESIGN AND METHOD.

This research was focused on two models of STL teaching (Model as such was defined against the amount of instruction teachers were equipped to teach):

1. STL teaching based on STL supplementary teaching material given to the teacher (Holbrook & Rannikmäe, 1997).
2. STL teaching based on supplementary teaching materials created by teachers during the workshops.

The following hypotheses were put forward:

1. Simply using new types of teaching materials (which include also a teaching strategy) is insufficient to change teachers' attitudes towards teaching science in an STL manner.
2. The process of developing STL materials by teachers is the major factor changing teachers towards STL teaching.

3. Through STL teaching, students gain problem–solving and decision–making skills.
4. Teachers' longitudinal change towards STL is linked with the creation of socially derived ideas for teaching science and the practicing of students centred strategies in teaching.

Twenty teachers, participating in the model 1 study, were asked to try out STL supplementary teaching materials without additional instructions and guidance. None of them had previous exposure to the STL philosophy. All information needed was gained from the teaching materials. Data were collected from teachers by interview. In addition, the teachers obtained 470 students opinions and written records collected immediately after the lessons. Data were validated by triangulation using the student written records, student opinions and teacher interviews. All data were qualitatively analysed, based on three domains: implementation domain (what students were learning and teachers teaching), attitudinal domain (opinions related to personal and social development), teaching intention domain (understanding the goals of teaching–learning).

Twenty five teachers, involved in the model 2 study were encouraged to develop their own teaching material meeting the STL criteria (see previous symposium paper) and to try it out in the classroom. During the six month intervention period, teachers attended three writing workshops (a total of 24 hours face to face contact), where STL supplementary teaching materials were created and modified and the draft versions of students pre– and post–tests created. All teachers were asked also to use already existing STL materials (Holbrook & Rannikmäe, 1997) and develop these, by themselves, into teaching material suitable for grade ten students. At the same time, the teachers were trained to recognise the need for wider goals for science teaching, to use student centred teaching approaches, develop problem–solving and decision–making skills and assess students on the skills gained.

Qualitative data were gathered to describe the process of teacher change. The data collection included the use of semi–structured pre– and post– intervention interviews with teachers, observations and student written records from all stages of the process of the development of scripts. Quantitative data were collected from 693 students. Test results were assessed by the teachers and later, separately, by the principal investigator against STL criteria (Holbrook, 1998). Teachers collected student opinions after they had been using the material created by teachers.

The post–intervention interview concentrated on outcomes and values of the intervention study i.e.

- Students achievements.
- Teachers gains and constraints during the intervention.
- Concerns which may influence the continuance of STL teaching.

The interview data were validated by triangulation against the workshop records. Students pre– and post–tests were created by the participants during the workshops. The structure of the tests was designed against STL criteria and was expected to assess, besides science knowledge, problem solving, decision–making and communication skills. The four test questions were sequenced, in a hierarchical order, accordingly the domain emphasised: factual recall and understanding, then problem–solving, then decision–making, and finally organisation and presentation of ideas. The marking scheme summarised all elements belonging to the same domain across the whole test. Outcomes were validated after the research by teachers participating in study.

The actual number of students taken part in the pre– and post–test was not equal. However the mean altered little by the addition or removal of these students. As no data was available on the number of occasions each student was physically present in the class (and hence the amount of actual instruction received), no attempt was made to undertake data reduction, matching students taking both pre– and post–test. The longitudinal influence of the intervention was studied 10 months after the end of the intervention by means of classroom observation.

RESEARCH FINDINGS

Teachers readiness to teach STL

STL teaching demands the stating of wider educational goals for the lesson, developing higher order thinking skills among the students and, definitely teaching in a student centred way (Holbrook & Rannikmae, 1997). In the teacher interviews in both studies (table 1), teachers separated subject knowledge from skills. Skills were linked with students involvement in the learning process, whereas knowledge was given by the teacher's talk, or the textbook. (i.e. 'to teach general properties of metals', or 'skill to write ionic equations using the table of solubilities'). Teachers' answers were not organised – most of their answers included fragments from the curriculum content and there was no balance between the subject oriented goals and more general goals. ('to teach logical thinking', or 'to understand the world around us').

Table 1. Number of Teachers stating one or more goals in each domain

Focus of goals	Model 1 Interview after STL lesson (teachers = 20)	Model 2 Pre-intervention interview (teachers = 25)	Model 2 Post-intervention interview (teachers = 23)
Subject knowledge oriented goals	18	25	23
Subject skills oriented goals	12	18	23
General Education goals	4	7	20

Table 1 illustrates that using STL supplementary teaching materials (which includes the list of goals and teaching strategies) is not enough to get teachers to recognise and value wider goals for teaching. The fact teachers do not pick up the emphasis of the materials they use, indicates how teachers were adopting new ideas into their common teaching. Teachers' change towards STL teaching took place through the intervention period where teachers began to acknowledge similar components of STL lessons as their students did.

STUDENTS OPINIONS ABOUT STL LESSONS

Students written responses, collected immediately after one single STL lesson, emphasised their recognisation of the possibility to think by themselves without subject centred guidance (27%). They noted they could apply science knowledge in solving everyday problems and communicate between each other (31%). Also 14% of students mentioned the STL lesson as something new and interesting in their eyes– something unusual.

Students open–ended answers were highly positive, but still influenced by the final examination demands ('these activities do not help us to pass the exam'). The same appeared within the long term study, where, in addition, the following domains were brought up by students (some students mentioned more than one domain)

1. Interested in the new activities (35,4%)
   '.....at the beginning we did not take seriously what the teacher suggested we do, it was not what we were used to doing .....new activities that we never use in chemistry lesson – we were drawing pictures. It was interesting, but we should learn the textbook too.....'
2. Communication and collaboration (55%)
   '.... I liked the groupwork, but there was a lack of additional material. My knowledge was not so good. It is good when strong students belong to the group; they can help the others. I am afraid I did not learn much knowledge for the exam, but I could discuss about interesting problems and analyse the graph showing the cleanliness of the school swimming pool water.....'
3. Problem–solving and decision–making in social context (72%)
   '..... it was easy to solve these tasks; they were taken from everyday life. I recognised problems that I never thought were linked with school chemistry......'

STUDENT ACHIEVEMENT

Science learning is always linked with conceptual development. New approaches to the teaching process should lead to gains in areas of focus, but conceptual development should not suffer. The Iowa SS&C project (Yager & Weld, 1999) showed that students achieved significantly better than in typical textbook dominated courses in each of the assessed domains: concept, process, application, creativity, attitude and world view. The current research outcomes (table 2) show the biggest improvement in problem–solving and decision–making domains. The slightly lower mean values in conceptual development were not significant and could well be explained by the different curriculum materials (metals, non–metals) assessed in the pre– and post–tests.

Table 2. Student Achievement and STL Teaching

	Pre-Test (N = 682)					Post-test (N = 623)				
Domain	Mean value	% students reaching score				Mean value	% students reaching score			
		0	1	2	3		0	1	2	3
Problem Solving skill (max. value = 2)	0.80	20	58	12	-	1.16	12	52	26	-
Decision making skill (max value = 3)	0.55	76	20	4	-	1.21	51	15	29	5
Skill to recognize Vales (max value = 1)	0.10	90	10	-	-	0.42	58	42	-	-

Domain	Mean value	Standard Deviation	Mean value	Standard Deviation
Science conceptual development (max. value = 9)	5.75	1.45	5.31	1.40
Communication skill development (max. value = 11)	5.40	2.30	7.22	2.12

In scoring student achievements in each of the domains, it was considered that:

- science concepts, factual recall, understanding and application is included in all test items (scores awarded in all 4 questions);
- communication skill was part of every open–ended answer (scores awarded in 3 of the 4 questions);
- problem–solving and decision–making were part of two questions (2 questions from 4);
- skill to recognise values appeared mainly in writing the essay (one question)

The marking of the test showed:

Following STL teaching, an additional 24% students succeeded in achieving a decision–making score; close to maximum scores were achieved by 25 % more students than before the intervention.

Students' change was similar across all the schools and classes, indicating there was very little (not significant) influence by the teacher.

TEACHERS' OPINIONS

Teachers who were using the ready made written STL material (model 1) continued to give the major thrust to concepts and skills related to science areas. Only very few teachers (4 from 20) saw the development of communication skill, creativity or co–operative learning as a learning component for students.

During the 6 month intervention (model 2), most of the teachers developed a more advanced perception regarding their role as facilitators of learning. The teachers increase their confidence to teach science (chemistry) in a student centred manner. They appreciated the students' motivational feedback, collected through the essay type answers after lessons where the material, developed by the teacher, was used.

Teachers did not recognise their growth in curriculum related knowledge and skills, as their marking scheme (even though it had changed) still gave a high emphasis to the role of subject knowledge. The fact that students' essays were more developed than in the pre–test was not noticed by teachers. Teachers were not familiar with strategies for assessing essays. Essays were marked against subject knowledge. On the other hand, teachers had a deep interest in the marking scheme used by the principal investigator and showed their interest in wishing to analyse their students' responses again. All teachers agreed with the increased students' achievement in the problem–solving and decision–making areas and, through that, recognised their change:

> '.....I did not think that I was teaching so differently. I just did my usual work and used STL materials and ideas. Maybe I really have changed. Maybe I was using approaches without acknowledging that I was using more problem–solving examples in my teaching. ... But I agree with that when I looked again at the test, and if I had marked the test against these criteria – I see many students did better. But a lot of that is not in the final examination....'

Besides the "hidden" change, teachers acknowledged their achievements in non–subject areas. Most teachers saw the greatest contribution of the intervention in the domains of teamwork, wider pedagogical knowledge and interdisciplinary knowledge. As all teachers involved in the study were teaching chemistry only, the need for wider interdisciplinary knowledge in solving daily life related situations become crucial. Many teachers promised to collect additional information during the summer to make the teaching material they had developed more justified. The process of developing teaching materials raised the teachers interest in publishing them. Here again the value of team work was highlighted and the need for looking through and discussing together all developed materials. The idea of the teacher as a researcher was acknowledged.

DISCUSSION AND CONCLUSIONS

These two studies showed the need for teachers in–service guidance for better understanding of the intentions of STL teaching. The STL modules helped teachers broaden their teaching goals, but did not clarify the STL philosophy of teaching. Using socially oriented, students centred teaching materials enhanced positive motivation of the students in learning science. Students appreciated the opportunities to think and develop co–operative learning skills, as well to apply science knowledge in new situations– relevant to students.

During the 6 month intervention, all 25 teachers changed. Students taught by teachers showed positive results and attitudes in STL related areas. As a major finding from the research, three categories of teachers were found related to STL ownership:

A. Subject learning activity based teachers (5 teachers).

B. Sequenced activity based teachers (8 teachers).

C. Social issue based teachers (12 teachers).

These categories describe teachers' change towards STL teaching and were developed from the following components:

- pre-intervention perception about goals for teaching chemistry;
- understanding about socially related problem–solving situations; acknowledgement of the need to assess against STL criteria;
- opinions about values education in the intervention.

The above factors were given a differing importance for each group.

Subject learning activity based teachers put continued emphases on facts and concepts, encouraged by the examination system. They placed dominance in assessing subject knowledge, even in socially related test items. They did not express the value of collaboration during the pre–intervention interview for the intervention. Supplementary teaching materials developed by them carried a strong science content, including applications as add-ons.

Sequence activity based teachers were a very mobile group of teachers. Although 8 teachers finally belonged to this group, this stage was passed by a number of other teachers during the workshops. These 8 teachers approached problem–solving situations overwhelmingly using scientific method.

There was a strong component of practical work in their teaching materials..

Social issue based teachers put emphases on problem–solving and decision–making, and sometimes value judgements were included in the teaching materials. This group of teachers developed well structured teaching maps involving social issues and showed competency in assessing students against STL criteria. Social communication was seen as the biggest value during the intervention.

CONCLUSIONS

1. To effect teacher change, it is essential to use techniques similar to the writing workshop, which give teachers ownership of developed materials and teaching methods.
2. Teacher ownership is important in directing teachers to follow developments and for motivation to work as a team.
3. Students gains in problem–solving and decision–making areas encourage teachers to acknowledge the need for change.

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Challenges in Science and Technology Education

Charoula Angeli and Nicos Valanides
(cangeli@cytanet.com.cy, nichri@ucy.ac.cy)
Department of Educational Sciences, University of Cyprus

AIMS AND SIGNIFICANCE

A teacher who transmits canned knowledge to learners, that is knowledge in the form of rules and prescriptions which is accepted unconditionally, limits learners' ability to think, reason, and test novel ideas (Langer, 1989, 1997). Therefore, the sheer presentation of decontextualized bits and pieces of information, which we call teaching, impedes learners from seeing the *relevance of formal education to real life*, as well as from applying or adapting existing knowledge in new contexts. Along the same line of reasoning, Resnick (1987), who also recognizes the dichotomy between learning in school and learning out of school, states that formal education with its emphasis on (a) individual cognition and not shared cognition, (b) pure mentation and not tool manipulation, (c) symbol manipulation and not contextualized reasoning, and (d) context-free learning and not situation-specific or context-bound competencies, does not adequately prepare students to be adaptive learners so that they can perform effectively when demands change. Thus, in essence, school knowledge remains inert (Whitehead, 1929).

Today, due to rapid technological advancements, we are living in a world that is constantly impacted by scientific knowledge as well as information and communication technologies (UNESCO, 1999). "The acquisition of new knowledge and its innovative applications result in a continuous transformation of our cultural, social and political environments. Existing knowledge is being rapidly revised and, in some cases, becoming obsolete" (Valanides, 1997). Some key-markers that characterize differences between 19th century societies (i.e., industrial-age societies) and 20th century[1] societies (i.e., information-age societies) are (a) standardization vs. customization, (b) bureaucratic organization vs. team-based organization, (c) adversarial relationships vs. cooperative relationships, (d) parts oriented vs. process oriented, (e) compliance vs. initiative, and (f) conformity vs. diversity (Reigeluth & Garfinkle, 1994). By virtue of these differences, we are obliged to evaluate, once more, the worth of our existing educational systems. Are our current educational systems with their emphasis on content coverage and teacher-centered classroom practices conducive to preparing students to survive in a changing world that is steadily shaped by developments in science and technology? How do we prepare our future citizens to become science-and-technology literate?

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[1] We consider the last part of the 20th century to be the beginning of immense developments in information, communication, and network technologies.

THE NATURE OF SCIENCE AND TECHNOLOGY

The relationship between science-and-technology and education is much more complex today than in the past (Newton, 1988). Technology initially grew out of personal experiences handed down from experts to apprentices. Today, there is a closer link between science and technology, a reciprocal relationship between the two, one could argue. This reciprocal relationship is established through a two-way interaction between science and technology. On one hand, technology depends upon scientific knowledge in order to devise tools to use this knowledge, and, on the other hand, technology provides tools for science such as reliable instruments for measurement, data collection, and computation. As technology becomes more sophisticated though, the demarcation line between science and technology begins to fade, and the distinctions between the two become blurred (American Association for the Advancement of Science, 1990).

The teaching of science and technology, in schools, has been traditionally interpreted to mean acquisition of facts and information for science education, and technical skills for technology education. We are arguing that this mechanistic approach to science-and-technology education is not an appropriate strategy for promoting science-and-technology literacy because: (a) it fails to inform learners about the relevance of science to real life; (b) it falsely regards technological literacy as a process isolated from the social context it impacts and it is impacted from; and (c) it fails to make the connections between science and technology, and most importantly, how science and technology impact societal problems such as environmental degradation, and food or water security.

THE SCIENCE AND TECHNOLOGY EDUCATION MOVEMENT IN SCIENCE EDUCATION

Within the context of science education, educators and researchers have gradually recognized the need to reform science education for the purpose of promoting scientific and technological literacy. Newton (1988) argues that current approaches to science teaching dehumanize science by emphasizing only its abstract processes and products, and not how it is closely connected with real life. To remedy for this weakness, current trends in science education are proposing new directions in teaching to ensure that science education responds better to society's needs and aspirations in the 21st century. New directions in science teaching include among others, the Science-Technology-Society (STS) and Science-Technology-Literacy (STL) approaches. STS, as advocated by Yager (1996), is both a philosophy and an instructional approach proposing ways of how science content can be taught so learners can realize the relevance of science to society. STL has been mostly embraced as an ideology of how to incorporate science learning within a societal area of study, thus STL, as Holbrook (1997) argues, is society driven whereas STS is science driven. We understand that the challenges for successfully reforming science education in accordance with STL or STS guidelines are numerous and multidimensional; but, for the purposes of this paper, we will only address the issues that we consider as challenges in designing learning environments for STL only.

AN ECOLOGICAL MODEL FOR DESIGNING LEARNING ENVIRONMENTS FOR STL

Undoubtedly, the old paradigm of instructional-design theory, referred to as the industrial-age paradigm (Reigeluth, 1999), focused primarily on the lower levels of learning within the cognitive domain. Specifically, the focus was on memorization (i.e., knowing that) and procedure-skill development (i.e., knowing how-to). Today, due to the fact that we are living in a world that is affected by rapid technological developments, the demands have changed. The emphasis is no longer on the lower levels of learning, even though they are still important, but on the higher levels of learning such as problem-solving, decision-making, and critical thinking (Reigeluth, 1999). In operational terms, citizens of information-age societies need to be able to think about and solve problems, work in teams, communicate, use information technologies, take initiative, and bring diverse perspectives in the learning situation.

Traditionally, instructional practices in science teaching emphasized, mostly, the fulfillment of lower-level learning goals, always predetermined by the teachers, at specific rates. In other words, all learners were expected to reach the same learning goals at the same amount of time. Therefore, science teaching has been viewed as a *mechanical process* of disseminating information to learners, that is a one-way interaction originating from the teacher to a group of learners. In this paper, we are arguing for an *ecological approach* to science teaching and discuss the challenges we are facing in implementing it.

The differences between a mechanical approach and an ecological approach to science teaching are fundamental. As the model in Figure 1 shows, an ecological approach recognizes the fact that social, cultural, and environmental factors, in addition to the cognitive, are important in the integration of new knowledge (Shapiro, 1994). In addition, an ecological approach to learning is a humanistic approach because it places the person, that is the student, at the center of the learning situation, and not the content. The teacher's role changes and it becomes one of diagnostician and facilitator of learning (Scott, 1987). In other words, the teacher forgoes his or her central role in the classroom, and recognizes the principle that the learner is responsible for his or her learning. Thus learners' thoughts, feelings, and beliefs are taken into consideration when designing learning activities. Most importantly, by placing the student at the center of the learning situation, it becomes possible for teachers to reach and address the needs of each student, thus *prepare all* for a fulfilling and meaningful life.

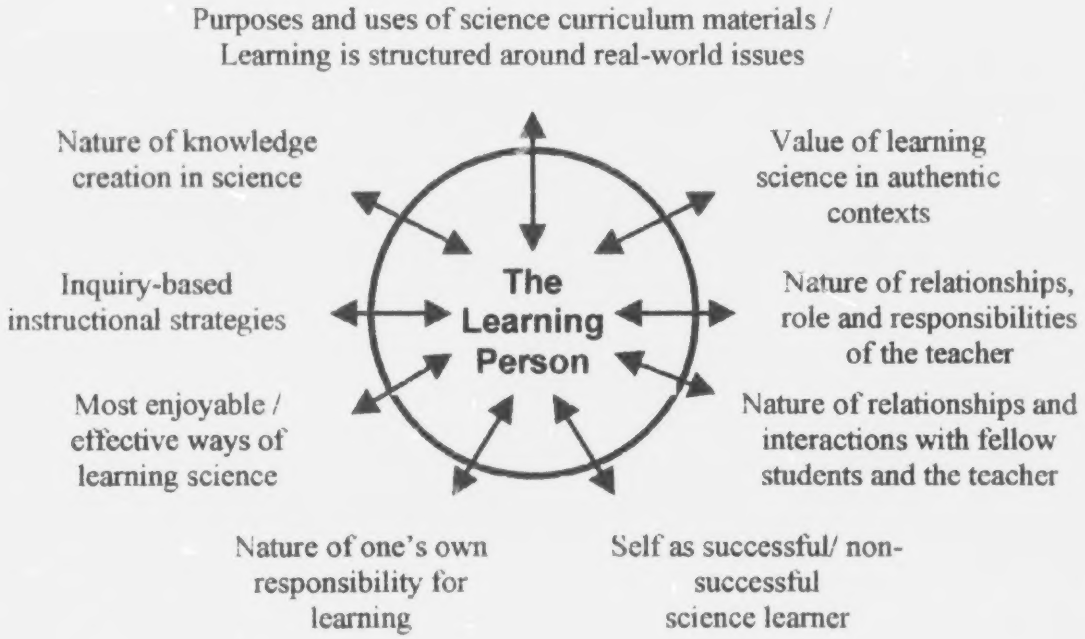
Purposes and uses of science curriculum materials / Learning is structured around real-world issues
Nature of knowledge creation in science
Value of learning science in authentic contexts
Inquiry-based instructional strategies
The Learning Person
Nature of relationships, role and responsibilities of the teacher
Most enjoyable / effective ways of learning science
Nature of relationships and interactions with fellow students and the teacher
Nature of one's own responsibility for learning
Self as successful/ non-successful science learner

Figure 1. An ecological model to science teaching (adapted from B. Shapiro, 1994)

Furthermore, in the proposed instructional model, learning is viewed as a human and social activity that takes place in inquiry-based environments; that is in environments where teachers and learners problem-solve and construct knowledge together. Thus, the learner is no longer considered as a passive recipient of information, but responsible for his or her own learning.

Ultimately, as shown in Figure 1, an ecological approach to STL is mainly concerned with how to connect content with its real-life functions. Put differently, how to situate abstract content in authentic learning activities, so learners can use the content in the same way that experts in the real world use it (Barab, 1999). Authentic activities consist of meaningful and rich problem-solving tasks that learners find personal, motivating, and enticing to undertake. The approach of ecologizing instruction is derived from the theoretical framework of situated cognition (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991). Situated cognition is based upon the notion that knowledge is contextually situated and is fundamentally influenced by the activity, context, and culture in which it is used. Thus, knowing is not objectively defined; that is, it is not independent of the situations from which it is constructed.

Central to the theory of situated cognition is the idea of designing macrocontexts, that is complex problem spaces which serve as environments for cooperative learning. In these macrocontexts, learners are engaged in solving problems that are complex and ill defined. Ill-defined problems allow for multiple interpretations based on different perspectives, and thus for multiple solutions. As Barab and Duffy (in press) state, it is only with ill-defined problems that students can take ownership of the problem-solving process. The implications of situated cognition in the design of instruction are not trivial, and thus the challenges in designing instruction are immense.

CHALLENGES IN IMPLEMENTING AN ECOLOGICAL APPROACH TO SCIENCE LEARNING

The biggest challenge to ecologizing instruction is to organize learning activities, not around the structured content mandated by school districts or ministries of education, but around projects/problems reflecting real world issues. This is the meaning of ecologizing or situating students' learning. Therefore, the challenge is how to build curricular units in a way so that students will be assisted in building grounded constructions from which they will perceive the relevance of the content they are learning to real life. The projects/problems should be interesting and motivating for students to tackle. Moreover, they should be challenging enough to create cognitive puzzlement in the learning environment, and thus, evoke students' higher order thinking. It is important though that the new curriculum will be designed to be appropriate for all students, and not too demanding for some, so it becomes possible for all students to participate. Lastly, curricular units must be dynamic in their nature, meaning that they must be upgraded regularly to address recent societal issues.

Another challenge, that originates from the above, is who will develop the new curriculum materials. Burkman (1987) explains that the products of instructional designers do not easily find their way to utilization because these products usually lack attributes that teachers value most. Teachers constitute a community of practice by themselves and share amongst them theories and values about the art and science of teaching, thus the classroom culture is too complex to be understood by someone who has not being part of this culture before. Therefore, to bridge this difference between what instructional designers develop and what is feasible in the classroom, teachers and designers need to work together to design and develop curricula that can be implemented in the classroom.

Even though the idea of establishing collaborations between designers and teachers is appealing theoretically, in practice it constitutes a challenge. Teachers are not trained to work as curriculum developers; therefore, teacher training is another important issue that needs to be considered. Teachers need to be trained to (a) find a balance between problem-based curricula units and meeting the practical constraints of classroom teaching such as improving scores, covering mandated content, and available classroom time; and (b) create curricular units that will be adaptive in their nature, so that instruction can be customized to meet the needs of each learner.

Last but not least, we will address the big challenge of training teachers to change their classroom practices appropriately, and in accordance with the ideology of the humanistic approach to science teaching. If we trace historically the outcomes of the many reform efforts that our educational systems and teachers endured, we will quickly come to the conclusion that teachers do not always share the excitement about new proposed changes. Therefore, they only adopt the portions of the reforms that have virtually no effect on their established practices. As Darling-Hammond (1990) explains, this happens because teachers view proposed educational change through the lens of the familiar. In other words, teachers' reactions to reform efforts depend on their pre-existing beliefs, values, and experiences. Therefore, as Myhre (1998) argues if changes are to take place in the classroom then new proposed teaching practices must be considered in relation to teachers' existing beliefs. It is of course a challenge to change beliefs within a short amount of time, but one way of confronting them is to use a training approach to help teachers become more reflexive and evaluative of what they believe. As mentioned previously, in the instructional model we are proposing in this paper, the learner is placed at the center of the learning situation. The teacher is no longer considered to be the sole source of information, but learners are expected to assume higher levels of agency in their learning (Scardamalia & Bereiter, 1991). Traditionally, the teacher has been the primary agent who dictated what needed to be learned, when, and in what sequence, neglecting the pedagogical value of the concept of the zone of proximal development (Vygotsky, 1962).

In this new paradigm, teachers and learners work together to problem-solve, decide, take action, and control the zone of proximal development. Therefore, teachers need to be trained to assume a different role in the classroom as well as function in an instructional environment that is more learner-centered than teacher-centered. Basically, the teacher needs to be trained to act as a coach whose job is to ask learners the questions they should be asking themselves. Furthermore, the teacher should not direct the learning to meet pre-specified objectives, but rather he or she should model for the students the thinking an expert assumes when he or she is confronted with the same problem to solve. Thus, the strategies of modeling, reflection, self-directed learning, cooperative learning, and Socratic dialogue become important as they can be used by teachers as tools to promote STL in the classroom.

In conclusion, we would like to emphasize once more that "there is a need to renew, expand and diversify basic science education for all, with emphasis on scientific and technological knowledge and skills needed to participate meaningfully in the society of the future" (UNESCO, 1999, p. 7). As we argued in this paper, the challenges in reforming science education are complicated and many, thus we would like to bring this paper to an end by saying that the success of a science reform movement will be maximized only if all stakeholders – teachers, learners, educators, designers, and researchers - work together towards meeting a shared vision and common goals.

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A Thinking Journey as a Means to Teach Astronomy to Wide Populations of Students

Yaron Schur, Weizmann Institute, Rehovot, Israel,
schurfa@netvision.net.il

INTRODUCTION

"One thousand two thousand" no, it is not the count of the millennium, but the count of the number of meteors that students saw on November 18th 1999. All the students of the school sat on the school's lawn from 11pm to 5am to watch the very special Leonide's meteors' shower. They saw thousands of meteors, and were reluctant to leave school, even in the morning. These were not students at a special school for gifted children, or a science academy. They were at a school for low functioning students where an experimental astronomy program has been implemented in the last eight years.

How can one explain the reasoning of a director of a school who chose to teach astronomy to a class of low functioning students at a middle school? There are so many prerequisites for learning astronomy, that perhaps one should put it at the end of the line. However, think of the possibility that these students will be able to demonstrate that they really can learn and succeed in astronomy. Perhaps one could use astronomy to enhance the students' cognitive skills and to foster their feelings of competence.

Astronomy is becoming more and more popular. Many News programs on the television all over the world include quite frequently items on astronomy. There are many books issued about astronomical subjects. Many popular movies deal with stories that connect with astronomical research. However in Israel there are not many schools that teach it in an orderly way, because it is considered to be difficult to teach and to learn.

A new approach to teach and learn astronomy is presented in this article, called "A Thinking Journey". The idea of "Thinking Journey" was developed for "A Thinking Journey to the Moon" program, which is now a part of the new Israeli Science and Technology curriculum for Middle Schools. The idea is applied now in several new programs in science and technology in Israel, including the comprehensive "Thinking Science" of the Weizmann Institute. "A Thinking Journey to Mars" is being developed at the Open University for high school students who don't major in sciences. The experience with astronomy teaching can serve also for other fields of science teaching.

A DIFFERENT WAY TO TEACH ASTRONOMY

The idea of the Thinking Journey was born in the classroom. The author taught astronomy to low functioning students at a school in Jerusalem, Israel. The idea was to try and find a way to teach astronomy in an interesting way with an emphasis on developing the students' cognitive skills. The theoretical framework related to the combination between two basic theories of the Constructivist and the Mediated Learning Experience – MLE, as the basis of teaching astronomy.

THE COMBINATION BETWEEN THE CONSTRUCTIVIST AND THE MEDIATED LEARNING EXPERIENCE APPROACHES TO SCIENCE TEACHING

The Constructivist approach to science teaching

The Constructivist approach to science teaching is based on the emphasis placed by Piaget upon the constructivist nature of the learning process. It makes the assumption that, from birth, individuals are actively involved in constructing their own personal understanding from their experiences. They construct meanings of events and phenomena as part of their attempt to make sense of the world. They base their conceptions on their direct experience with the physical world, (Driver and Oldham, 1985; Williams and Burden, 1997).

Teaching science, according to the Constructivist approach, views learning as the reorganization and development of students' conceptions. This demands the consideration in science teaching of the alternative concepts that learners have constructed and promotes the active construction of meaning on their part, (Driver and Oldham, 1985).

The Mediated Learning Experience – MLE – approach to science teaching.

The Mediated Learning Experience (MLE) approach to science teaching is based upon Feuerstein's view of the human being as a changing entity, who is constantly learning how to survive in the various environments that she encounters during her life. Learning science or any other subject matter is viewed as an interaction between an individual and an external environment that demands that this individual modify herself. Her ability to tackle the demands of her learning environment can be enhanced by experiencing mediated interactions. These interactions focus on the relevant cognitive processes. Feuerstein's assumption is that through the enhancement of cognitive functioning the learner will improve her performance in subject matter learning, (Feuerstein, Rand, Hoffman and Miller, 1980; Feuerstein, Feuerstein and Schur, 1997). One has to identify the relevant cognitive processes involved in the learning of scientific subject matter and design the mediated interactions and enhancement of these cognitive functions around this scientific context. Then, the cognitive processes developed through these mediated interactions can be generalised to enable students to learn other areas of content.

The combination of the Constructivist and the MLE approaches to science teaching

The Constructivist approach places considerable demands on the science teacher.

This article argues that the combination of the Constructivist approach and Feuerstein's MLE approach can be beneficial to the science teacher. The Constructivists offer a map of what should be achieved in the science class, while MLE describes a process enabling movement from one place to another on this map, and relates it to the environment.

The Constructivist and the MLE approaches both relate to processes of change. The Constructivist approach addresses the factors that influence the student's initial concepts and deals with the process of conceptual change, while the MLE construct is concerned with the cognitive processes that are needed in the interrelations between the human being and her environment. The Constructivist approach determines the expected course of development of a concept in the student's mind. The MLE approach identifies the variety of thinking paths that a student may take in the course of the development of the concept, and promotes the student's ability to re–organize accordingly the way she observes different environments.

The combination of these approaches enables the use of focused mediation which relates specifically to the position of the students vis–a–vis the concept. This combination also allows the use of flexible mediation that takes cognisance of the variety of thinking processes that can be used in the process of conceptual change. Further, it promotes a reorientation in the learner's relationship with her environment which enables her to observe it from a different perspective.

The main ideas of the "Thinking Journey"

A Thinking Journey involves the design of a learning situation according to a combination of the MLE and the Constructivist approaches. It structures a broad encounter between the learner and the environment with provision for the intervention of a mediator. The basic encounter is not with scientific models or formulae but with focusing on the place of the learner and on the process of observation of phenomena. In order to be able to relate the scientific concepts to the everyday reality of the learner, she has to be able to connect the scientific concepts to the way she observes natural environments she encounters in her everyday life. The process of change can occur when one takes the learner to a journey to observe the known environments from a new point of view and to connect these observations with touring other environments that can be compared to her everyday one. What is important is not to stay at the level of constructing the story of the faraway place but to return to the everyday environment and to reconstruct its story.

The use of cognitive functions enables one to acquire the relevant cognitive tools that are needed in order to construct a thinking journey. This can affect the cognitive functioning of the learner while dealing with physical environments. It can also affect her ability to relate to her everyday environment.

A Thinking Journey is based on observations of a physical environment from different perspectives. Each perspective enables the learner to construct a different "story" (explanation) of the environment. The coordination between the different perspectives is the basis upon which the learner constructs her new concept of the phenomena that are seen in the environment, which means observing the environment in a new way.

The idea is to enable the learner to observe the place where she lives from a new perspective. People often go to great lengths in order to be able to observe themselves from a new perspective. The ability to distance oneself from the usual point of view of the near environment is a first step in the process of a conceptual change thereof. The process of conceptual change usually comprises a movement in the mind of the learner from the initial concept towards the scientific one. Vosniadou (1994) refers to the synthetic mental models that children construct in the process of combining the initial models of the concept of Earth with the scientific one. Vosniadou's approach concerns a two way interaction in the learning process: the one involves the individual in learning about the characteristics of the scientific concept and adopting a more scientific point of view while the other is the influence exerted by the mediator on the way the learner observes her environment.

Understanding this interaction is important in the process of constructing teaching materials. The planning of the journey takes the learner to the places where she can observe both her initial and the scientific concepts. For example, relating to the concept of the Earth, the initial concepts stem from the everyday perspective of observing the environment, while the scientific model can be observed through the use pictures of the Earth from space. In constructing a Thinking Journey, one can enable the learner to get to places where she can observe the relevant perspectives. This process allows the learner to get to space and learn the scientific understanding of the Earth through mediated interactions with a variety of pictures of the Earth as seen from space. Then the learner can return to a given environment on Earth and observe it in a new way, being able to relate to it as a part of the Earth.

DIFFICULTIES IN ASTRONOMY TEACHING

Astronomy and Space Science have a strong appeal to children. It is a dynamic and exciting science, which is deeply rooted in their everyday life and in the surrounding culture. However the use of astronomy in the classroom encounters usually some basic problems. The regular astronomy teaching can make the interesting subject of astronomy a very difficult and hard work that only a few students in the classroom can understand. The main difficulty lies in trying to teach a vast field of knowledge in a very limited time. The astronomy teacher often asks herself how can she not teach this important issue and not mention this important concept. This makes the usual astronomy teaching a race against time to teach a lot of "strange" words and concepts without enabling the students to really understand the context of where these terms stemmed from.

IMPLEMENTATION OF THE IDEAS OF THE THINKING JOURNEY IN ASTRONOMY TEACHING

a. Relating to the place of the learner

The teaching is done through explicitly determining the place of the learner. There is not a body of knowledge that is disconnected from any context that the learner has to learn. The body of the knowledge is incorporated with the different contexts, where the learner is going to observe its different ingredients. The place of the learner is important and explicit throughout the learning process. The learner is not the outside observer who watches the phenomenon. The learner is a part of context. She can observe the same phenomenon from many perspectives and in every one of them the scientific concepts will take a different shape. In order for the learner to really understand scientific concepts, one has to use them in the context of different environments and connect them to the everyday environment of the learner.

Teaching should involve going around new places, and observing phenomena from different perspectives. Their observations give students new "glasses" that enable them to observe their environment in a new light that is related to scientific concepts, but also gives the students the opportunity to really observe their environments. It is the everyday use of these glasses that is so important. The science class should aim to influence the way students observe the world. This is a cultural influence.

b. Touring new worlds

The idea of the Thinking Journey is to make the students "tourists" in their own environment. In order to make it interesting and new, they have to look at it from a new perspective. This explains the need to get out and relate their environment to other ones with other features. Like the young people that are going to visit far away places in order to really understand themselves, the going out is essential in our desire to have some new perspectives on our own environment. Pictures are used as a tool for meeting new environments. Using pictures needs a special kind of mediation.

Relating to the different "worlds", which we see as points of light, can make astronomy an interesting learning subject. In their most interesting book, the famous astronomers, Miller and Hartmann (1993), take the reader to the various worlds that construct the Solar System. One can go from one most interesting place to another, as a tourist. One can see incredible sights. One does not have to be an expert astronomer to enjoy the grand tour around the different celestial objects of the Solar System.

This is the basic idea of using the "Thinking Journey" in astronomy teaching, to take the students to other celestial objects as tourists, and to teach science through the observation of phenomena in new environments. The power of scientific visualization through pictures and images makes such a journey an exciting learning experience. Furthermore, the introduction of new technologies (3D animations, Virtual Reality) can enhance the visualization capabilities the teacher can use, allowing him to simulate actual flights over the terrain of other planets and to study them as if observing from a spaceship in orbit.

c. Constructing the stories of the places where the journey goes to and then retelling the story of different environments on the Earth.

The thinking journey to the moon leads the learners to the moon, where they can construct a story of an environment that they can compare with the one they know from the Earth. They construct the story of the environment of the moon and include in it how different phenomena show up in the moon. For example: The day's length and the night's length is two weeks of Earth time each, sunset and sunrise take a whole Earth day each, the Earth is always in the sky of the "near side" of the moon, and it is never seen from the "far side", one can see while standing on the moon (electromagnetic waves can move in the airless moon) but one cannot hear or light fire in the airless environment, gravity acts on the moon etc.

Coming back to the Earth after staying some time on the moon can make the learners observe their environment on Earth from a different perspective. They are shown different pictures from different environments on the Earth, and they are able to see them in a new perspective. They can observe phenomena that resemble the moon, and some other phenomena that show the uniqueness of the Earth, its dynamic environment and the special conditions that let life live on it.

d. Using a friendly communication language – pictures.

Since many students have difficulties with mathematical skills, ways must be found to enable them to interact with the physical environment, while circumventing the mathematical obstacles. Using pictures of the Earth, the moon and space, enables students to interact with a congenial modality. The term "modality" is borrowed from Feuerstein's "cognitive map", which is his the description of the various cognitive dimensions of learning tasks. Feuerstein, Rand, Hoffman, Egozi and Ben–Shachar (1991 p. 168) define modality as the language of presentation of a learning task.

Students find the pictorial modality familiar: they are accustomed to it in their everyday interaction with television, movies and computers. Perrig and Kintsch (1985) observe that the pictorial modality is easier for students to remember and to understand than the verbal modality.

The pictorial modality is the most common way of conveying astronomical data. The use of up–to–date NASA pictures enables the students to learn by observing these phenomena and building on their observations in the generalization process. They can wander around distant places in their minds, like tourists. They can also construct stories that these distant places tell. Even the most distant place can seem quite concrete to the students. This kind of modality enables the students to become acquainted with the nature of phenomena. The question that the students are asked is: what do you observe around you? They relate to data gathering and elaboration from observations, without the need to construct models, which can distract them from really observing the new environments. Photographs from space constitute scientific information regularly used by astronomers, so that their use in an astronomy curriculum seems natural. The students are given the pictures and asked to analyze actual scientific information contained in them. The fact that this information is given in the congenial pictorial modality represents a sound reason for using unmodified photos from space as the basis for the curriculum's interactive mediated activities.

Contact with the physical environment involves relating to an abundance of stimuli. The pictorial learning tasks can provide learners with tools to find some organizing principles in the physical environment. The students learn that the environment can offer something new on every encounter. The ability to ask new questions and to observe the changes can enable students to predict what is going to happen in some phenomena in the environment.

Photographs are useful in enabling students to construct a representation of whole environments. They can relate simultaneously to complex phenomena, and they are able to construct an image of these phenomena. Further, the process of mediated interactions enable students to form connections between different pictures.

This process enables students to construct a "story" of the phenomenon, as if they were travelers visiting it. The most important part of the process is to relate back to the students' everyday environment and to use the experiences from the far away places as a means to reconstruct the "story" of their everyday environments.

e. Teaching science in an unexpected way – Putting a question mark to the obvious

Take two students who pass a ball to one another, which is a very simple action on Earth, and move them to the moon or to other celestial objects, and questions will arise: Is there gravity out there? Will they see the Earth up in the sky or down below their feet? What is the connection between gravity and directions? Will the students be able to communicate with each other? The change of environments can lead to a much more interesting way of teaching scientific laws and to understand the fact that they are conserved also in remote celestial bodies. Students learn that the same scientific laws can take different shapes in different places. For example, gravity acts on both, the Earth and the moon. However throwing a ball on Earth is different than throwing a ball on the moon where gravity is much weaker.

Relating even to simple concepts like day and night becomes complex and interesting when we deal with other environments. How does day and night look like, when we observe the Earth from the moon? Understanding that day and night mean phases, and that they are important qualities of planets, is a new understanding of the simple concept.

f. Mediated interactions based on observations

The Thinking Journey is based on a series of mediated interactions. The whole picture is constructed by the learner through the accumulation of the perspectives of her experiences with various interactions. The active role of the teacher as a mediator is important in enabling the learner to connect her different experiences and to acquire tools to improve her learning skills.

The Thinking Journey relates to a cyclic learning process where each interaction is composed of six stages (Schur (1998)). Usually, when a teacher goes out with her students to observe some phenomena, she thinks that her students see what she wants them to see. Her mediation takes for granted the fact that the children saw the facts that she had presented to them. However in many cases the children do not see at all what the teacher expects. In other cases children see different things than the teacher expects. So a learning session should start from listening to what children actually see around them, and in which context do they put the scientific phenomena which they observe.

The guiding principle of this process assumes that for learning to take place children should perform learning tasks involving the subject matter, with the active mediation of their teacher. For studying astronomy, children are initially asked to observe a phenomenon (either directly in the sky, or in an image from space). They are then guided (by targeted questions referring to the image) to define and collect the results of their observations. Then, they analyze the data, explain it and look for interconnections between different items. At this stage, the teacher (tutor, instructor) supplies additional information, as well as guidance and counseling. The children then draw conclusions, generalize the observation and look for rules (or natural laws). The last stage is an introspection of the previous stages, to create awareness and as a preparation for a repetition of the process to the next assignment (=observation). This is a dynamic learning process where students are active participants in the acquisition of knowledge, rather than passive recipients of information.

The use of cognitive processes enables students to become more active in their relationship with their environment. The activity and flexibility of students can be amplified through interaction with a human mediator.

g. A Thinking Journey is a choice to concentrate on one or two worlds rather than teaching the world of astronomy.

Teaching astronomy is usually considered difficult because of the vast amount of knowledge it contains and because of the abstract nature of it. One should make a choice either one teaches a lot of concepts in a vast field of knowledge or one chooses to concentrate on one or two worlds, and concentrate on them.

The choice of the thinking journey is to give the students the feeling of competence and of being able to explore new worlds. If they will enjoy their astronomical studies, even if they will lack some knowledge, they will find ways to return to it via the internet or in other places.

Results and Discussion

1 The "Thinking Journey to the Moon" was taught in a class for low functioning stu-

dents in Jerusalem, Israel. Results demonstrated that the program was more effective than an Earth Studies program in promoting a process of change in the conceptualization of Earth, notwithstanding the fact that the explicit aim of the latter program was to teach the concept of Earth. Earth Studies had been implemented for years at the school included in the study, and was taught by skilful and experienced teacher.

Moreover, the "Thinking Journey to the Moon" program was also successful in improving the students' knowledge of astronomy, enhancing their general scientific knowledge, and developing their cognitive functioning and problem solving ability.

2. The emphasis on knowing other worlds can enable students to understand the fact that they live also on a similar world. This can give them a new perspective to observe the place where they live.
3. The use of pictures, films, computer programs and other means that use a lot of visual information is going to become greater in the coming years. Using the visual mode of communication requires a different way of teaching, with an emphasis on the process of observation. The mediation process that involves the use of cognitive functions enables students to acquire cognitive tools that can make them better observers in other learning situations.
4. The ideas of the Thinking Journey can serve to enable teaching astronomy to wide population of students. It may also serve as another way to teach interesting and complicated bodies of scientific knowledge to wide population of students.

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The Science Classroom of the 21st Century

Zdravka Kostova, Sofia University,
elena@netplus.bg

The science clsssroom of the 21st century is shaped by the concepts discussed, the context situations and strategies of learning and the interaction and communication between peiple. Its main aim is to prepare students for integration in society for meaningful personal and social lives.

Science education standards and the responsibility of the international scientific society. The challenge to improve science education must be met by the whole humanity and by everybody as science is the basis for sustainable economic development. One way of doing that is the development of national science education standards corresponding to the international state of science, the requirements of the society and the students` needs for today and future adaptation to life.

In our country the educational reform started with the development of state educational requirements (standards) on the basis of the new school reform framework, which were adopted a year ago. Science subjects are integrated in a new cultural and educational sphere, named "Science and Ecology". It comprises the school subjects: Physics and Astronomy; Chemistry and nature conservation; Biology and health education. A new integrated subject was introduced in the primary and middle school (from 2nd to 6th grades), named The Human being and Nature. The boundaries of the different school subjects are somewhat loose as the problems of environmental and health education are problems of each school subject and because ecology is still understood as nature conservation. For each subject the core curriculum and the expected students` achievements are outlined at two levels: First – empirical (the standard minimum) and Second –more theoretical (for students interested in biology). It is obvious that there must be minimum requirements for those who are not going to pursue a career in science as science is an essential part of modern culture. The future state of science depends not only on those who make or will make discoveries but also on citizens who pay taxes and on the members of parliament who make decisions. Future members of Parliament and future voters are now at school. So R. Marzano is quite right when he says that the society of tomorrow will be the same as the classroom of today.

The problem is how can the discrepancy of fast scientific progress from the low progress of school reform be overcome? How could the future scientists be motivated and stimulated to work hard and think creatively? My impression is that science education deteriorates as education becomes accessible to more people and as the school population increases due to the increase of the human population.

In many countries the introduction of new science education standards is under experimentation and improvement. This is a profound step forward to put science education on scientific bases. But the problem is that the international scientific society, though doing a lot, is not cooperating efficiently enough and is not closely involved in the matter. Two activities need greater stress here – conceptualization and contextualization of science education. Conceptualization refers the key concepts and models for understanding of issues concerning nature, environment and human life. Contextualization involves situations in which key concepts can be made meaningful to students. Conceptualization involves also elaboration of well established science concepts, introduction and discussion of new concepts as science is continuously being developed.

The programs "The Human Genome" and "The Human Brain" and the school reform. In biology teaching great emphasis is made on traditional branches of biology, such as classification, identification, anatomy and physiology, ecology, cytology, biochemistry, evolution etc. This is all very good as in this way students learn the scientific language and gain some understanding of the mystery of life on Earth – the unique product of evolution. Definitely the attention payed to the achievements of the two programs "The Human Genome" and "The Human Brain" is not enough but they profoundly revolutionize human life and human thinking.

The full understanding of the human genome is well into progress and the achievement raises a host of scientific, medical and ethical questions. In the words of president Clinton "Today we are learning the language in which God created life…Genome science will have a real impact on all our lives – and even more on the lives of our children. It will revolutionize the diagnosis, prevention and treatment of most, if not all, human diseases". As the research is going faster and faster, the students as citizens should be prepared for the implications of the new discoveries. They should be prepared to make safe decisions on the basis of sound information. We often say that information in teaching no longer matters. But are we honest?

The benefit for curing major human diseases including cancer, heart diseases and genetic disorders is obvious. Once genes are understood and their proteins are unraveled, it could become possible to create new diagnostic and therapeutic approaches. It is becoming increasingly easy to test people for genetic predisposition to certain disease and everybody would like to know that for himself. Putting that into practice is not an easy matter. Who will pay for the tests and who will guarantee that the results are kept secret or honestly used? How will that affect the ignorant and poor part of the society? Will that create new ethnical problems?

Obviously the new discoveries in biology require quite a new approach to science content standards and to science teaching and finally to teacher` professional development. They will affect not only biology teaching but the total science teaching and Humanitarian subjects as well. What is of utmost importance is the introduction of Bioethics in the biology curriculum.

The challenge of bioethics. Bioethics develops due to intensive discussions in connection with biology, medicine, ecology and conservation, genetics and many other branches of science. It involves some aspects of the new technologies including the new information technologies. This concept is very broad and multidimensional. It could apply to ethics in nature, ethics towards nature, ethics through nature and ethics among human beings. Ethics in nature as far as I understand it is the relationship between individuals, between species and human species and nature. Support and symbiosis is not less common than competition in nature but textbooks stress competition. Seeds will find it difficult to germinate, if they do not push the earth together. Such is the case with carnivores, having a socially organized way of life, etc. The human civilization will not survive if it lacks ethical behavior to nature implying all forms of life, if it cannot share the earth with other living things. Ethics through nature, I think, means that behaving ethically to nature we behave ethically to other human beings including future generations. No living species can survive without a suitable environment to which it is adapted. No species including the human species and no concrete individual can survive without its ecological niche. Unemployment is depriving people of their ecological niche and is against natural ecological laws. And finally comes the indispensable significance of ethics among human beings. I am sure we all shall feel much happier and much healthier if we help instead of fight one another. Fighting is such a waste of biological energy, is it not?

Those are some of the reasons why I appreciate the implementation of a European Module on Bioethics in Universities, which raises the question of introducing such a module in the Secondary schools as well. It is too late to start at the University level. Science without ethics may prove to be very destructive. Civilizations have disappeared not because of lack of food but because of lack of morality, have they not? Here comes the question: "Are we ready to the new discoveries?" A. Caplan stresses the necessity of preparing people for the flood of new genetic information about ourselves. He calls the genetic news "big news" and points out that we have not guarantees that will make the genetic revolution user–friendly. In addition to that is the effect of the new discoveries on the stock market. We have the right to experience not only joy but also great fear with respect to the new biological discoveries as their application is not only scientific but also political, moral etc. That is why I think the topics of the European module on Bioethics quite reasonable (//A:\BIOETHICS EUROPEAN MODULE.htm):

1. Bioethics – scope, object and methodologies;
2. Background information on current aspects of Biotechnology and trends in Ethics;
3. Concepts of life – various approaches;
4. Concepts of dignity in life and dignity in death: euthanasia;
5. Eugenics: Gene therapy, Biomedical practices etc.;
6. Experimentation on humans and animals;

7. Environmental ethics – Societal aspects in Europe;

8. Human Genome Project.

In connection with the discussed problems is the problem of school discipline and ways to deal with it. We can wish ourselves easy solutions of the problem in the coming new millenium but all of us are quite sure that the problems will become even more serious. That is not a reason to overlook it but on the contrary – a reason to pay even greater attention to it in the school standards, in research and in the professional development of teachers. Each teacher should be prepared to deal with discipline problems, with bullying and aggression in the classroom and out of it and also to be able to prepare students to meet and cope with such problems. Solutions are necessary not only to make science studies possible but also to ensure the survival of students and teachers in the classroom. Many are the causes to the increase aggressiveness in children:

a) a breakdown of families, *b)* some children are forced to raise themselves as they are left by their parents or their parents are working and preoccupied, *c)* aggression is everywhere – in the street, in the school, at home, on the media, etc.) children have difficulty adapting to the multiple environments they live in, *e)* the gangs fighting and shooting are making their ways into classrooms.

Those real and heavy problems need classroom management techniques. They also need mutual agreement on the rules that students and teachers should follow in their collaboration and communication.

The inquiry approach to science teaching. The inquiry approach is not new. Since its first application and elaboration by Henry Armstrong at the end of the 19^{th} century it has undergone a lot of transformations and improvements but has never quite left the science classroom. Now it is coming in full bloom. No science classroom can be real without it. The inquiry approach (scientific method) has different meanings in different contexts. In biology teaching it means studying biology in the way scientists discover new facts or putting students in the role of scientists (to step in the shoes of d real scientist) and think and act in the way they do. Studying and acquiring scientific concepts is not enough as that can be done by rote, where simple memory is involved. But *formulating problems, elaborating hypotheses, designing and carrying out experiments, collecting data (observation), verification, graphing data, analyzing and interpreting data, making inferences and discovering new problems,* make the scientific study real and fascinating. The pleasure of having made a discovery, even a discovery for your own, is very strongly motivating. In the classroom students discover already known facts and relationships but that does not spoil the pleasure if it is done in the proper way. The best thing is to start with observation in nature and let students ask questions. Most of their questions are scientific problems and they can be tackled using the scientific approach.

Teaching science as inquiry helps students to acquire scientific skills and proposing hypotheses is one of them. The hypothesis is a proposed relationship to be tested, a concept in need of validation. Two types of variables are taken into account – the independent and the dependent variables of the studied phenomenon. A hypothesis allows the students to predict what will happen to the dependent variable when the independent variable is manipulated. This way of teaching helps students to experience real science. Therefore carrying out controlled experiments is the nature of biology, otherwise it will be necrology.

Presentation in the classroom of the work performed and ability to make themselves understood is of utmost importance. It needs ability to communicate science to others. Presenting data in the form of tables, plotting graphs and discovering relationships is indispensable. All that provokes comparison, critical thinking and stimulates procedural learning. In this way students not only acquire skills but also develop their own strategy of learning.

Acquiring life–skills in biology teaching. The present–day life is very risky. To have very great knowledge of science and to be able to apply the scientific approach is not enough to adapt to very often a hostile environment. More important is to acquire and develop life–skills that can help the child (the student) to overcome or to avoid risky situations. What are life–skills? People have different opinions on the concept life–skills. The best approach to the problem is to identify the risks and than think of the skills needed to cope with them. Having that in mind we performed a survey of 100 biology teachers' understanding of life–skills (table 1).

Table 1. Teachers understanding of life–skills

1. Behavioral skills	Knowledge of life, habits, understanding of cultural norms
2. Interests	Curiosity, studiousness
3. Experience	Making observations and inferences, learning from mistakes, repetition, undertaking training
4. Mode of life	Attitudes to life, accepting and making rules and obeying them, strong will to live, adaptations to life, abilities to exist and to withstand difficulties, perseverance, ambition, searching advice and help, charity, understanding of the problem, common sense, sense of humor, self-fulfillment
5. Working skills	Industriousness, dexterity, precision, performance, use of experience of somebody else, effective functioning
6. Communication	Mutual aid, empathy, tolerance, honesty, correctness, understanding, responsibility, intra- and interpersonal intelligence, listen to others, collaboration, responsibility to the health and life of other people, interactive, participating, social integration, prioritization, does not push too hard, consistent
7. Disposition	Able to enjoy the moment, positive emotions and attitudes, personal happiness, able to control emotions, stressors and wishes, avoidance of depression, emotional stability, psychological harmony
8. Thinking	Solve problems and make decisions, critically, scientific, open, search for meaning, systematizing, making inferences, empirical, theoretical, abstract
9. Psychological processes	Watchfulness, analysis, concentration, synthesis, memorize, impressions, sensitivity, imagination
10. Values	Evaluation, life respect, collaborative, valuing life, "Life is worth more than its sense", self-conscious
11. Personality	Responsiveness, independence, positive self-esteem, self-confidence purposefulness, health (physical, psychological, emotional, social, etc.), steadiness, persistency, effort, endeavor, strong will, flexibility, culture, compromise, discuss, organize, self-composed in unknown situations, ability to face the problem, making mistakes and learning from them, ready to help, kindness, able to wait, patient, assertiveness, to receive and give support, self-responsibility, easy socialization, open to learning, fighting for freedom and respecting freedom, brave, determined,
12. Environment	Support from the family, friends

Life–skills and personal characteristics are interwoven as human personalities solve problems. The skill for problem solving can be a key concept for new associations. It is a life–skill of priority, emphasized by all teachers. Their understandings of life skills vary as the life situations also vary. Life–skills are learned in life but students can be helped in consciously developing them. Some of the technologies of helping students are the Force–field analysis, analysis of prejudices, visualization, brainstorming, role playing and analysis of specially designed strip cartoons.

Example of innovations in science teaching. At the beginning of the 21st century the amount of information is no longer a problem of priority. What matters now is the strategy of learning, which is a product of the way of teaching. Interactive teaching involves new dimensions of learning and a new kind of relationships in the classroom. In R. Marzano's words it means to use the new dimensions of learning: Attitudes and Perceptions; Acquire and integrate knowledge; Extend and refine knowledge; Use knowledge meaningfully; Productive habits of mind.

The student can be approached in three ways. The first one is represented by the authoritarian teaching, when the information flows from the teacher to the student. In this case the student is totally dependent on the teacher. In the second way the information circulates between student – student, teacher – student and student – teacher. The dialogue is the leading teaching strategy. In the third way students acquire procedural knowledge using the inquiry approach in different situations. They learn from books, from observations and experiments and from the group memory.

Methods and approaches:

The method of associations. Based on the brain physiology and first of all, the synapses in the brain. Procedure. Each student prepares a piece of paper, half a page, and a pen and is ready to write down his associations with a key word, given by the teacher. The teacher gives the word and the students take down their associations for three minutes in the order they come to their minds. Each student then makes a model of his associations on a whole page. The model is based on Buzan's theory of radiant thinking. At the centre of the page the key word is written. Then each association is written around the key word and is connected with it by means of an arrow. The first circle around the key word represents the main associations. Each word from the first circle is a key word for associations connected with it. Then comes the second circle and so on. The students work in pairs, making a model of pair associations. Then in groups of fives, preparing a model of group associations. The leader of each group presents the model of the group associations to the whole class and a model of class associations is constructed. In this way a picture of a cultural model is constructed, which shows the associations of the students, that are at the top of their minds at the time of work. In the process of constructing the model the students explain to each other first and then to one another what they have in mind. The work provokes discussions and clarifications of the concepts involved. It may stimulate further search for clarification from books. The teacher may collect the pieces of paper from the students and work out a model of associations using his criteria of classification and then the two models are compared. In the process of discussion students share the differences in their understandings and clarify them or ask the teacher. They look for blank places in their associations and try to enrich the model. As a result a picture of the concepts, connected with a main topic is prepared, which is easily remembered. Each student can work with the model on his own and make it in the way he likes best – may colour it, may use different types of letters, may use drawings and so on. The students share their personal ways of visualizing the discussed matter.

Key words: biodiversity, cell, nucleus, nucleic acids, bones, ecology, environmental equilibrium etc.

The methods of content analysis and mind maps. The content analysis can be defined as analysis of the hidden (implied) and evident sense of the contents of a definite volume of written or oral information on the basis of predetermined criteria, by means of classification and presentation in the form of diagrams, tables, mind maps and evaluation, using their heuristic value for making innovative conclusions. Of course the analysis is performed with the aim of determining the effectiveness of the contents under evaluation. Many researchers think that the method of content analysis is very useful in analysing a great amount of information, because it helps to grasp it, to expose the trends and to draw attention to those of them that are of priority.

Application. In educational research the method is used to evaluate the conceptual or terminological overburden of the textbooks' contents. The main steps of the content analysis are as follows:

1. Determination of the criteria for evaluation: a) specific terms, given with explanations; b) specific terms, used without explanations on the assumption of the textbook authors that students already know them from the previous courses.

2. Preparing a table with three columns: First column for criteria *a*, second column for criteria *b* and third column for remarks.

3. Careful analysis of the contents on the basis of the criteria. Filling the table with the results. Each student or teacher (in the courses for teacher training) is working independently.

4. Discussion. One of the students is reading the first column of his table and all the other students underline the concepts which are mentioned. Then each student reads the concepts, which are not mentioned. The participants discuss the arguments for including them in the first column of the table and accept them or not with consensus.

5. The same is repeated with the second column.

6. Each student reads the first column and marks the concepts which are already known with "+". The same is repeated with the second column.

7. Decision making. Using the results in the first and the second column students make conclusions about the accessibility of the contents. They ask questions about the meanings, which are not clearly expressed.

8. The students propose a key word, connected with all concepts. It is usually taken from the title of the topic or lesson. The key word is written in pencil at the centre of a cardboard (paper). The concepts are classified. The main concepts are written as a first circle around the core (key word). Each concept from the first circle is connected with the key word by means of an arrow and then used as a key word for associations in the third circle and so on. As a result a mind map of all concepts in the given topic is constructed.

9. Students use coloured pencils to make a colourful mind map. They can accompany the concepts with drawings and visualize them.

10. Discussion. Now the students try to find out the relationships between the concepts and make conclusions. In this way they discover hidden meanings, cause and effect relationships, basic principles, etc.

Significance: The content analysis and mind map constructions are very useful techniques for independent work of each student, interaction and collaboration of students and for decision making. They develop skills of the six levels according to Bloom's taxonomy of educational objectives.

Content–analysis is very useful in educational research. It's application proved to be very fruitful in textbook analysis, in developing criteria for a choice of a textbook from teachers on the basis of expert analysis, in construction of intellectual models of concepts, in developing a strategy of learning, in solving problems, in overcoming conflict situations and so on.

The mind maps should be called intellectual maps as they are products of human intellect. They are not simply registrations of memories that come to mind. The intellectual map of the concepts in a given lesson helps students to remember them. It is a visual aid in learning. It can be used as a tool for preparation to competitive exams. The teachers can use them as an evaluation instrument and in many other ways. They have indispensable role in development of different types of thinking: critical, analytical, integrative etc.

Rules for intellectual map construction:

1. Take care of the priorities that should be stressed in order to stimulate your memory and creativeness.

2. Use a central image as it draws the attention and the mind as well, as it is attractive, unlocks the associations, gives pleasure. The central image is more active when instead of a word a drawing is used.

3. Use images (drawings) any time you construct an intellectual map. Do not hesitate. With each attempt you'll get better and better. Open your eyes to reality.

4. Colour the central image in three or more colours.

5. Draw the images in three dimensions.

6. Connect the images with your senses – sight, hearing, smell, taste, touch. Do not

hesitate to use rhythm, expressed by repetition, sequence, movement, exaggeration, feelings etc. Make the intellectual map as lively as you can and capturing. Use symbols of movement.

7. Use different sizes and shapes of the letters to imply hierarchy, sense of categories and relations of cause and effect, of subordinations.

8. Leave the map open so that it can be enlarged and enriched.

9. Pay attention to image and word location.

10. Leave spaces around the words and images so that they can be perceived and thought out and interpreted.

11. Use associations as they make the remembering easier.

12. Use codes, symbols etc. to connect the words and images.

13. Make the maps clear because if they are not, they will retain your studying and thinking.

14. Every word or image is a centre of many associations. On one line write only one word.

15. Use print letters as they have clear outlines and can easily be remembered.

The use of intellectual maps in studying the lesson "Genetic variability" Biology, tenth grade.

Preparation of the lesson:

1. Individual work of the students with their textbooks at home. Three textkooks were analyzed – two alternative textbooks, used in Bulgaria and one German textbook, used by the students, studying biology in German. Preparation of intellectual maps of the concepts.

2. Group work. Working in pairs students consulted each other and improved their maps of concepts. Each student prepared a short presentation on chosen concepts, but not less than two. He was allowed to use illustrations, short oral composition, photographs, pictures, drawings, experiments etc. according to the meanings of the concepts, which are discussed and in conformity with his understanding and visualization.

3. During the classroom studies, all of the students were making a class intellectual map of the concepts. The teacher was constructing the map on the blackboard and the students were working with their notebooks. A new intellectual (mind) map of the concepts was prepared which combined the contribution of all students on the basis of consensus. In the process of making the map students gave their presentations, clarifying the concepts.

4. Final work. Students look for relationships and principles and make conclusions from the maps.

Expert learning. is a new interactive form of learning, which stimulates communication between the students. It helps them to develop personal strategies of learning and to communicate their understandings to others, to socialize and integrate themselves into the school community.

Steps in practical realization of the technique.

1. Preparation of written materials on the topic to be studied.

2. Classification of the materials into sets on the main tasks for studying the topic. Students are divided into groups according to the tasks of the lesson.

3. Distribution of the materials into groups so that each group should have a set of the materials, connected with only one task.

4. Each group studies the materials thoroughly.

5. Students rearrange into new groups. In each group there is a representative from any of the old groups.

6. Each student in any of the new groups is a teacher to the other members of the same group.

7. In this way every student is a teacher to the other students. If there is a problem, the teacher is ready to help.

8. The original groups are restored and each student reports the problems, posed by the members of the group he acted as an expert.

Advantages of this method. All students actively participate. The results can be seen immediately. Students acquire not only new knowledge but also methods and skills to communicate and present knowledge and to develop personal strategy of learning. It saves time and stimulates scientific interest and desire for learning.

Disadvantages. More difficult to prepare. The teacher should be sure about the preparation of the students so that they do not communicate knowledge they do not understand quite well.

Brainstorming. It means a temporary mental tension, caused by uncontrolled emotions and strenuous mental work. It is a method of education, connected with generation of ideas in order to solve a problem. The method is very useful, when the problem cannot be solved by one student. It combines individual with different levels of group work. It begins with posing of a problem and proceeds by the following stages:

1. Formulating a problem and writing it on the blackboard.

2. Specifying the aspects of the problem to be solved.

3. Dividing the students into groups according to the aspects and on their wish.

4. Each student generates ideas for solving the particular aspect of the problem. He writes them down, each idea on a separate sheet of paper. Each student creates at least 10 ideas.

5. The sheets of paper with the ideas are piled up with the text upwards for the whole group. The names of the students, who created the ideas, are not written on the sheets.

6. After the ideas are collected in a pile, the participants in the group start analyzing them one by one. The main criterion for analysis is the usefulness of the proposed solutions. The ideas are arranged into a hierarchy. The ideas giving the best solutions are written at the beginning and after them – the more abstract ideas.

7. A list of all ideas is prepared. If on two sheets of paper, the ideas coincide, one of them is discarded. If there are new ideas, generated in the process, they are written down and included in the list. The list of hierarchically arranged ideas represents the strategy of the group for solving one of the aspects of the problem.

8. All the groups collect and start discussion of the solutions proposed by each group through its reader. The other groups can pose questions and can improve their strategies.

9. A list of ideas for the solution of the different aspects of the problem is prepared and it represents the strategy of all the students for the solution of the problem.

Advantages. All students work creatively and collaborate with one another. The ideas are not criticized and no idea is discarded. Each student is equally participating. There is no dominance of anyone whatsoever.

Disadvantage. It is time consuming and cannot be broken as the students' enthusiasm is cooled down.

Application. Our lives are sets of problems . Each of us confronts them. Some professions are nothing else but problem solving e.g. discoverers, designers, researchers and so on.

The process of brainstorming is very closely connected with radiant thinking. The intellectual maps are the external expressions of radiant thinking. Brainstorming can be used in different ways and in different parts of the learning process. It is closely connected with discussion, project work, evaluation and decision making.

We applied it in environmental and health education. In environmental education it was combined with role playing on the problem of forest conservation. The role play was performed to find out the answer to the problem: "Why do trees die?"

The discussed interactive methods comprise only a small part of the innovative approaches to teaching. The difficulties, connected with their application are mainly due to teachers' competences in using them. There is nothing new in the conclusion that innovation in teaching depends on innovation in teacher training. But if we want a new kind of a classroom, we have to introduce innovations which not only stimulate creativity, but also promote collaboration and mutual respect.

Teachers professional development. On the basis of the discussed problems, a training course was organized with teachers from 18 to 22nd of December 2000 – I phase. The topic of the course was "Biology and Biological Education at the Beginning of New Millenium"and 48 biology teachers participated. All of them apreciated the course and expressed their wish to attend the second phase of the course in July, 2001.

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Teaching Photography: An Interdisciplinary Theme for Science, Technology, and Art

Dimitrios Stamovlasis, University of Ioannina, Greece
me00550@cc.uoi.gr

ABSTRACT

This paper addresses contemporary concerns with the disintegration of meaning and fragmentation of knowledge. It appeals to interdisciplinary curricula, where an effort is made to reveal the interactive relationships among different fields of knowledge. The paper proposes Photography as an interdisciplinary theme, which involves Chemistry, Physics, Technology and Art and gives an outline of the relations and the patterns that connect these fields. Teaching Photography can provide links across disciplines and in addition it would provide a context for experimental work and problem solving. In photography experiment, STES–oriented curricula could find the basis for developing a dynamic interplay between Science Technology and Art. The proposed interdisciplinary teaching appeals mostly to higher level of education, universities, colleges or professional schools.

KEY WORDS: Technology, Photography, STES– oriented curricula, Fine Art.

INTRODUCTION

In science education curricula, there has been for decades, a strong commitment to disciplinary strength in physics and chemistry. That choice has resulted in failing to strengthen the links between Science, Social / Life Science, Technology or Art. On the other hand, research in science education has shown that there is a need for interdisciplinary knowledge for dealing with the contemporary society's problems. Although most school curricula follow the transitional way, there are some exceptions, where an effort has been made to focus specifically on the interactive relationship among Science, Technology, Environment and Society. In these STES programs are emphasized the social and environmental implications of the development of science and technology (McFadden, 1991). The incorporation of technology education into curricula bridged the gap between science and society. Scientific knowledge is recognized as key to technological development and that development either as a process or product affects human values within the society.

There has been an epistemological debate about the relationship between technology and science. The dominant view accepts *technology as applied science* (Gardner, P.

1994). This view is based on the assumption that scientific knowledge precedes development of technology. Although technology is consider, as a practical application of scientific theory, there are historical examples that do not support this position. Bell's telephone system was developed in a period where the electrical properties of carbon were unknown. Photography also was invented in a period where chemistry as science did not exist.

The alternative position on the relationship between technology and science states that technology and science are independent to each other and that *technology precedes science* as an intrinsic feature of all cultures (Custer, R. 1995). An intermediate view conceptualizes science and technology as interactive, each contributing to the development of the other.

Fine Art, on the other hand, has been taught as a separate discipline having its own core–elements and its own defined boundaries. Contemporary Art is often close related to Technology applications and in addition artists need to posses scientific knowledge to an adequate level.

Pedagogical implications for education arise from an epistemological consideration of the nature of the technological/scientific knowledge. Is that different from scientific knowledge? Can it be characterized as "content" or "process"? Different emphasis in the balance between conceptual and procedural knowledge has been over time in both technology and science education. These differences actually reflect different emphases of the educational goals within the two areas, and different pedagogic traditions (Murphy, P. and McCormick, R. 1997).

No matter how clear the educational goals and teaching objectives might be, a practical issue of a great importance arises. That is, how to translate these objectives in a STES–oriented course into teaching strategies and assessment methodologies (Zoller, 2000). A difficulty also arises when we have to draw a border line between science and technology or between scientific / technological procedural or conceptual knowledge. When we say that we do science or we do technology. An analogous question holds and in an educational frame of teaching Fine Art.

ON PHOTOGRAPHY

A STES–oriented educational program designed to focus specifically on the interactive relation of science, technology, environment and society, needs interdisciplinary themes to develop curriculum within these expectations. These themes will be the sources of providing teaching material and practical work.

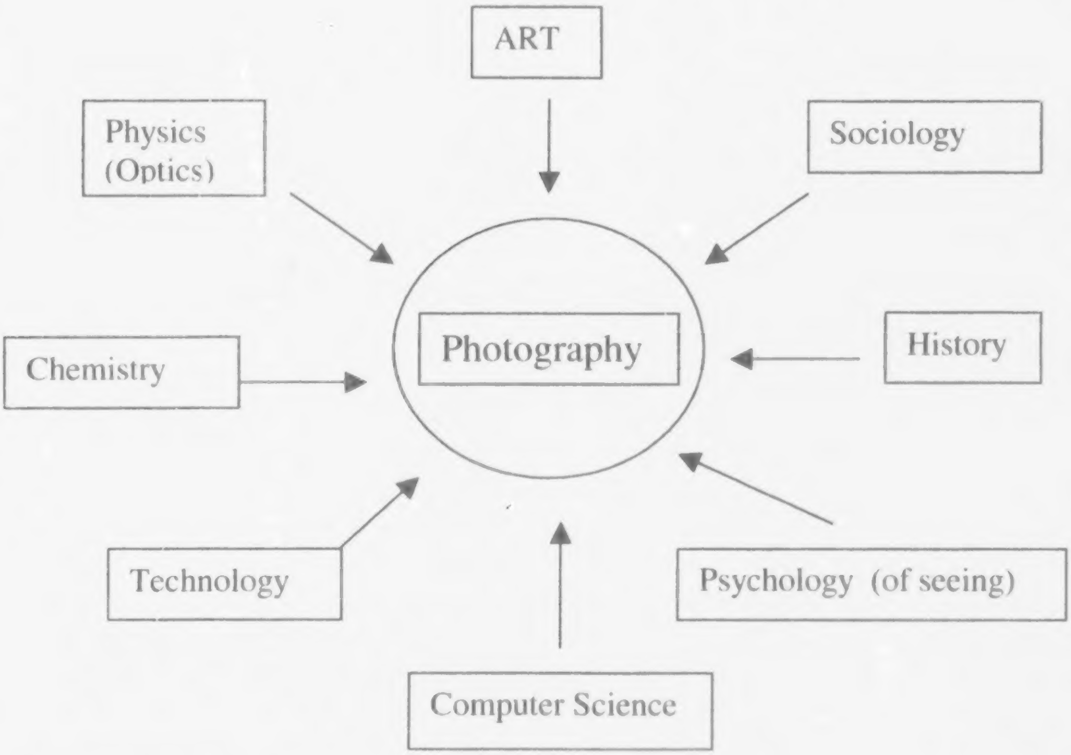

Figure 1. The interdisciplinarity of Photography

We propose that Photography could be such a source, which could provide material for supporting a combined STES program. The interdisciplinarity of Photography is shown in figure 1. Photography is related to physical and to social science as well. It involves a lot of Chemistry and Physics interweaved with Technology. On the other hand a Photograph can be in the center of interest of many social science such as psychology (visual perception), Sociology, Communication, History, Computer Science (digital Imaging) and Fine Art. All the above make Photography being a unique theme, which could approach a variety of fields and provide a context for teaching basic element of chemistry, physics and their technological applications.

Even thought the advances of technology have made Photography as a process a straightforward one, students have always are interested in disenchantment with the 'mystery' of Photography. Photography is very popular among students and sparks their interest to be involved with it. That can make for them a purpose for learning and in addition would provide a context for experimental work and problem solving.

The research literature on intrinsic motivation for learning (Martinez and Haertel 1991) has shown that the dimensions form different models may be organized into three clusters, the cognitive appeal, the mastery appeal and the social appeal. Photography incorporates those dimensions: stimulates curiosity, provides experimental work that lends a sense of effectiveness and enhances sociability.

TABLE 1. Science, Technology and Art in Photographic procedure.

	SCIENCE	TECHNOLOGY	ART
PROCEDURE			
Choose the scene	Light, filter, theory of color		Art-education semiotics
Focus	Linear optics	OPTICS: Lenses	
Choose aperture And speed	Photometry photochemistry Exposure conditions	Use and understand technology equipment	Applying technology to control image aesthetics
Choose Developing time	Control of chemical kinetics	Applying 'trial and error' methods	Control image appearance
Film Development	Photosensitive materials, color production	Use and understand technology equipment, film technology	
Choose the paper		Properties of photographic emulsion	Control image aesthetics
Find printing time – Print the photo		Applying 'trial and error' methods	
Use the photo			Art-education

A sequence of actions or steps, which describe the procedure of making a photograph, is shown in Table 1. There is a broad spectrum of knowledge types, (content or skills) involved in this process. The instructor has the opportunity to introduce basic concepts of physics, such as nature of light, properties of light, linear optics and technology of optics (lenses and geometry of image formation). Chemistry is the other scientific field that can be approached by photography. Concepts of oxidation–reduction could be introduced with experimental work. Factors affecting a reaction, such as pH, restrainers, etc could be studied.

On the other hand, the product, a real–apparent image concerns Mass Media, Communication and Semiotics.

Figure 2 shows patterns that connect Science, Technology and Art, provided by photography.

EXAMPLES OF TOPICS INTERRELATED IN A INTERDISCIPLINARY TEACHING

A dynamic interplay between chemical kinetic and Fine Art

When a photographic material is developed, those silver halide crystal, which have been exposed to light and bearing a latent–image center, are reduced to metallic silver Ag by a reducing agent:

$$AgCl + Red^{-} \rightarrow Ag^{\infty} + Br^{-} + Ox \qquad (1)$$

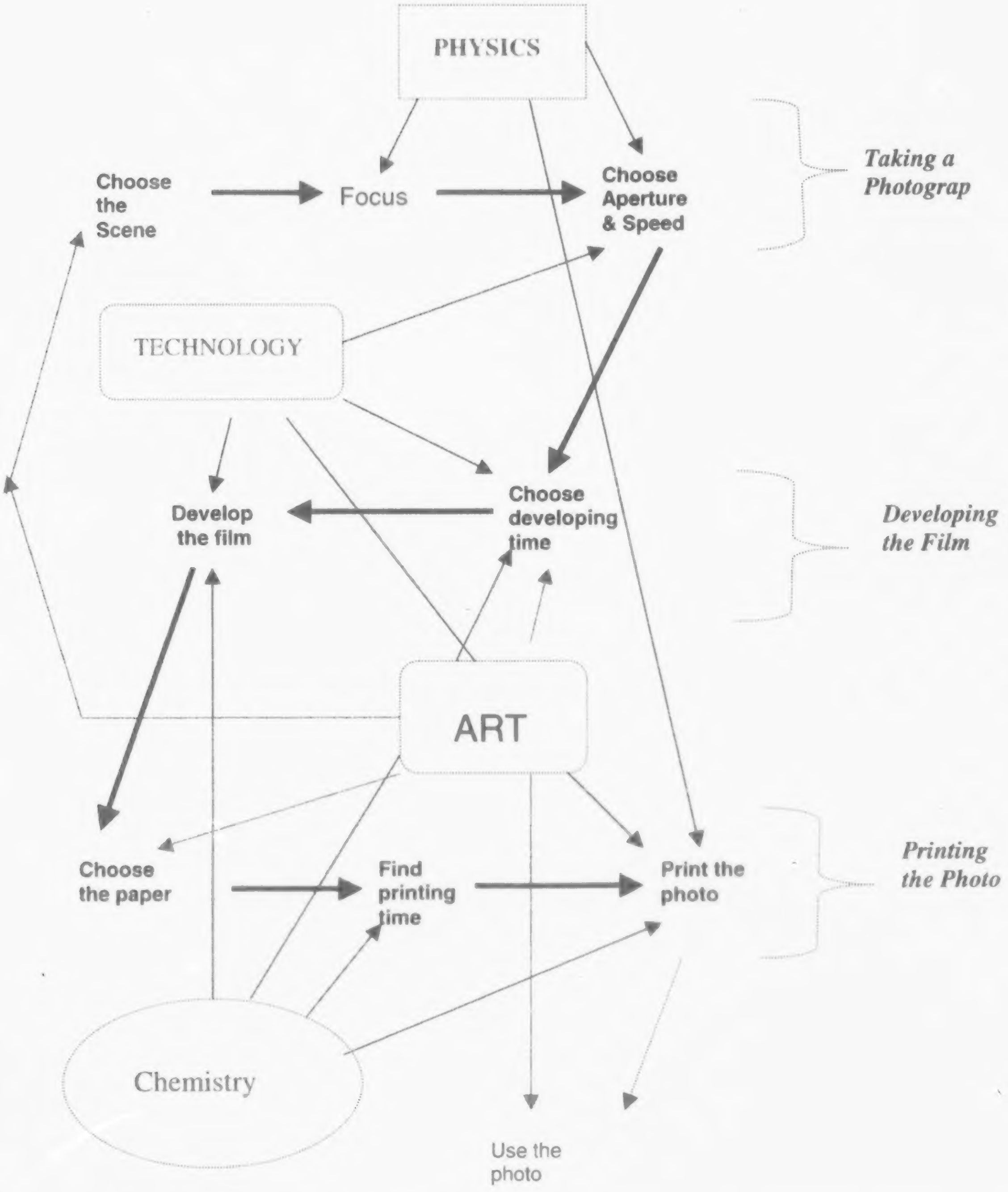
PHYSICS
Choose the Scene
Focus
Choose Aperture & Speed
Taking a Photograp
TECHNOLOGY
Develop the film
Choose developing time
Developing the Film
ART
Choose the paper
Find printing time
Print the photo
Printing the Photo
Chemistry
Use the photo

Figure 1. Patterns that connect: Physics, Chemistry, Technology and Art in Photographic process.

Where *Red–* is the developing agent, and Ox is its the oxidized form. The amount of metallic silver formed on a developed transparent emulsion can be estimated by measuring its optical density, *D*. If the optical density *D*, which depends on the geometry of the measuring apparatus, is plotted versus the logarithm of exposure $H= E * t$ (in lux*sec), the characteristic curve is obtained. (Keller, 1993). The slope γ of the linear portion of the graph is the *contrast* of the photographic image. *Contrast* concerns the number of gray tones of the image that exist between absolute black and absolute white. The control of contrast, which is based on a kinetic effect, serves as *artistic expression*. Controlling factors that affect the rate of the reduction reaction, such as temperature or concentration of reducing agent, affect the appearance of the image. Thus the instructor can integrate the chemical kinetic.concepts within an Art frame following a dynamic interplay between science and fine Art. This interplay involves the microscopic and macroscopic level. The macroscopic level that concerns Fine Art can be understood in relation the rate of a chemical reaction at microscopic level.

Teaching experimental design using sensitometric procedures

The proposed experiments appeal to a university level course on experimental design. The photographic procedure dealing with a multifactor chemical system is used to collect data for an advanced statistical treatment and introducing chemometrics (Stamovlasis, 2000). The proposed experimental work concerns the determination of a photographic parameter, *the contrast*, γ, which is the slope of the characteristic curve of a photographic film. In practical sensitometry the determination of Á has been based on the "single–factor–at–a–time" approach. This work is a stochastic approach to development kinetics of a photographic emulsion. The obtained stochastic models predict *contrast* as a function of temperature, developing time and concentration of reducing agent. The results are useful to a professional artist photographer and to the college photography Lab, if available. This work is a demonstration of using easy popular experiments in a Fine Art frame to teach advanced statistical methods.

Project works

The process of creating a photograph (figure 2) involves 'content' and 'procedural' knowledge, that is knowledge, which consists of understanding basic scientific theories, and knowledge, which is of 'know how' type. Instead of using explicit teaching on design and technology, that is describing a set of preordered behaviours, one can organized project work based on the intension to investigate or to evaluate something. A simple example could be an 'investigation' of the effect of color temperature of a light source on the appearance a color photograph. That connects physics and chemistry and within technology education can provide the context of proposal making and enhancing active and reflective capabilities. These project works can be designed and evaluated within a dynamical model (APU, 1987) demonstrating the interplay between thought an action.

Other interdisciplinary projects

Interdisciplinary projects connecting also social and physical science can be designed as well. Photographic Aesthetic, through its history from collodion to hydroquinone (Newhall, 1982) has been related to chemical materials and method used. Thus, patterns that connect Chemistry, History and Art can be drawn, and which contribute to reduction of fragmentation of knowledge.

CONCLUDING REMARKS

The paper proposed that Photography, because of its scientific, technological and social dimension, interrelates many topics and fields and that makes it a suitable context for interdisciplinary teaching. Photography can provide STES–oriented curricula with easy and interesting experiments for practical work and problem solving. The interdisciplinary approach applies to chemistry, physics or technology teaching, but also in teaching of photography itself, replacing in this way the rote learning of applying pre-ordered procedures with constructivist meaningful learning.

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Evaluation of the Latest Physics' Book Prepared for the 1st Year for Professional Oriented Classes of Technical Education in Cyprus

Papageorgiou Angelos, Technical School of Nicosia Cyprus
agpapge@cytanet.com.cy

Key words: Evaluation, Book, Physics, Technical School

INTRODUCTION

The research haw had been done under the encouragement of Mr. Christos Neokleous Inspector of Physics in the Ministry of Education and Culture and the help of the Institute of Education of Cyprus (1).

The goal was to evaluate the book of Physics prepared by a team of Teachers working in the 'Programs Developing Center' of the Ministry of Education and Culture.

The book was taught for the first time to the pupils of the 1st year of Professional Oriented Classes during the academic year 1999–2000.

The evaluation of the book took into account the views of both Teachers and Pupils who had been using the book during the above academic year.

Therefore two different questionnaires had been developed. One for the teachers and one for the pupils.

These questionnaires were independents, but special attention was given to include some similar questions. By doing so, we were able to compare the evaluation of teachers and pupils in similar themes.

Similar questions were also included in the above two questionnaires in order to check the reliability of the answers.

The teachers' questionnaire included 45 questions, which were divided in the following five subjects:

a) General goals and scopes of the Physics

In this topic we put some questions concerning the promotion of the general educational goals and targets as well as of Physics in particular.

b) Contents

In this part we had questions for the setting up and presentation of the various topics of the book, the standard and scientificity of the glossary used in the book, the support provided to the pupils by the pictures.

c) Exercises

We had questions concerning the evaluation of the exercises of the book

d) Introductory Experiment

For each lesson of the book there was a number of introductory experiments. Therefore we had questions to evaluate the optimum time needed to prepare and conduct these experiments and to evaluate the contribution of these experiments in building up the interest of the pupils as well as to appreciate their assistance in helping pupils to understand the lessons.

e) Instructive Method

In this topic we tried to evaluate at what extend the book proved to be a valuable instrument for the teacher to the general programming of the lesson as well as the preparation and teaching of the lessons.

VALIDITY OF THE CONCLUSIONS

The questionnaire answered all the teachers that taught the specific lesson during the academic year 1999–2000 and 242 from 1012 pupils that used the specific book.

The Gronbach Alpha coefficient is 0,98 for the teacher's and 0.95 for the pupil's questionnaire.

The standard deviation for the pupil's questionnaire is Û=0.02.

For a population of 1000 a sample of 260 gives an error less than 2% for the 99 of the 100 samples (2).

The T–test given us the following conclusions:

The influence of the character 'sex' in the two questionnaires and the character 'teaching experience' in the questionnaire of the teachers are not very credible because of the small sample of females in the two questionnaires and teachers.

The influence of the characters 'I like/don't like the lesson' and 'I understood/didn't understood the lesson' for the pupils sample is strongly certified.

The validity of our conclusions is supported by the internal coherence of our results, of the proximity of the results in similar questions in the two questionnaires and the results in questions that are presented visa–versa in the questionnaires.

GENERAL CONCLUSIONS

In this paper I will present some of the general conclusions that were provided by the analysis of the answers in the two questionnaires.

We must underline that these conclusions are valid only for pupils in an educational status similar to those of our sample.

The generalization is not always evident.

Teachers

The teachers who answered our questionnaire, in general, were more positives than the pupils in most of the aspects related to their lessons.

A more close analysis has reveled, that their opinions were less positive from the pupil's opinions whose attitude towards the lesson of Physics was a positive one and /or declared that they understood the lesson (denoted as 'positive' pupils for the rest of the paper) and more positive from the pupils that have a negative attitude towards the lesson and/or declared that they didn't understand the lesson (denoted as 'negative' pupils for the rest of the paper)

The opinion for the possibilities of pupils of such an educational level is more negative between the less experienced teachers than the more experienced ones.

The teachers have good approximation in their estimation for the degree to which their lesson (Physics) is pleasant for the pupils. This estimation is very close to this of the pupils and it is negative.

It was obvious that the more experienced teachers (ten or more years of experience) use the instructions of the book in their didactic approach and the programming of the lessons less than the teachers with less experience (up to five years). It seems that they don't need so much help as the less experienced ones.

Finally the less experienced teachers are more positives in 'knew ideas' of teaching (experiences, self education of the pupils, cooperative learning etc.) than the more experienced one.

Pupils

For the pupils, their general idea for the lesson (if they like it or not), and their 'understanding' of the lesson are predominant for their whole attitude towards the lesson of Physics.

The character 'understanding' is a precondition for the character 'like the lesson'.

These two characters are very important because they diversify very strongly almost all the answers of the pupils in the questionnaire.

So it is clear that in our educational approach we must emphasizes the character "understanding' in order to rise the number of pupils who 'like' Physics and have in general a positive attitude towards the lesson (character of a very important specific weight).

Taking into account the results from the pupil's questionnaire, we came to a conclusion that the pictures of the book are in general more important from the experiments for the 'understanding and interest for the lesson.

A more close examination reveled that this is true for the 'negative' pupils. But for the 'positives' pupils although the 'images' still to have a big importance for the above two characters the 'experiments' are more important.

That means that the 'experiments' are constructive for pupils who are 'positive' towards the lesson of Physics and 'understand' more or less of what is happening during the experiment (that is difficult for feeble pupils).

As concerning the teachers, although they don't deny the importance of the pictures, they declare that the experiments are more important.

We must also keep in mind that about 15% of the pupils they had find out many or too many unknown words in the texts of the book. Another 10% declare that they didn't understand at all or say that they understood a few (39%) the texts of the book.

It is clear, that with such conditions, the goal for self–education of the pupils is not realistic.

We have found out that a 15% of the pupils have a very negative attitude towards the lesson of Physics.

That means that two to four pupils in a class of twenty will probably cause seriously problems in the process of the lessons.

Finally we have to point out that about 50% of the pupils dispose less than 10min to do their homework for the lesson of Physics.

The book

According to our results the book is quite satisfactory in the most of the educational issues (the educational level of the text, the exercises etc., vocabulary, attitude..).

The main problem of the book is the time that is predicated for each lesson.

It is clear that the book has a central role to the whole didactic of the lesson. It has to be adapted to the educational level of the pupils as well as the teaching approach.

Therefore it's evident the cooperative role of the book and the teacher.

A schoolbook in my opinion has to be evaluated by part, in the procedure of the writing and not as a whole, with some precautions.

More precisely

We have already discussed for the importance of the images for the 'interest' and the 'understanding' of the pupils.

Although the specification of the targets for each lesson of the book is very helpful for the teachers, it's not so helpful for the pupils as the summary that was included in the previous book.

Despite the fact that the colour is a positive character and contributes a lot in the aesthetic of the book, it is not so important according to the pupil's answers to arise their interest for the lesson. But this conclusion must to be more investigated because it is not strongly confirmed.

Finally, I propose that the evaluation of the book (and all books) must be a continual effort in the frames of the whole educational system. It was very helpful for me, in the analysis procedure of the questionnaires the fact that I taught the specific book.

STUDY FOR THE EDUCATIONAL STATUS OF PUPILS THAT ATTENDED THE 1st YEAR FOR PROFESSIONAL ORIENTED CLASSES IN THE A′ TECHNICAL SCHOOL OF NICOSIA IN CYPRUS FOR THE ACADEMIC YEAR 1998–1999

From 304 pupils, 33.3% was graduated from the 'Gymnasium' (College) in Jun, 51.9% in September and 14.8% was repeaters.

The following table gives the marks of the pupils in the final exam of the year in the Gymnasium.

MARKS	LITERATURE	MATHEMATICS	HISTORY	PHYSICS
0–5	5%	8.1%	7.4%	4.6%
6–10	72%	62.9%	72.6%	80.1%
11–15	21.5%	22.1%	19.7%	15.1%
16–20	.9%	0.6%	0.3%	0.2%

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3 Iro Palochi: Study for the educational status of pupils that attended the 1st year for professional oriented classes in the Aã Technical School of Nicosia in Cyprus

The Relation Between the Implemented and Attained Curriculum for High School Preparation Science Based on the Third International Mathematics and Science Study (TIMSS)

M.H.Yarmohammadian, Medical University of Esfahan
mhyarmohamadi@hotmail.com

Research into the Science curricula for the aims and purposes (the curriculum intended), implementation of education (i.e. implemented curriculum) ramifications and outcome (i.e. the attained curriculum) help instructors to fathom the strengths and weaknesses of the existing curricula and improve them.

This study has been designed and implemented for this very purpose and that of elucidation of the status of implementing education, attaining the learning of the course science and also discovering and locating such factors as age, sex, grade, etc. contributing to the academic achievement of students in Science.

General Aims

1. Evaluate and study factors contributing to the academic achievement in science of High School Preparation students.
2. Study the relation between the implemented curriculum and the attained curriculum for the High School Preparation Science.
3. Recommend guidelines to improve the High School Prepatation curriculum and teaching of Science.

Specific Aims

1. Study the attitudes of Science High School teachers to the concept and teaching of Science.
2. Study the relation between the various factors pertaining to the student, teacher, school and the family on the one hand and the academic achievement in Science of students on the other hand.
3. Study and decide on the proportion for contribution of each factor referred to earlier and the differences in their contribution.
4. Study the differences in the academic achievement of students in the issues presented and / or not presented in Science by High School teachers, tec.

Methodology

The present study has been conducted by utilizing the data collected by the

Educational Research and Planning Organization functioning in an administrative capacity for TIMSS study. Due to the use of such data for the study of the relation between the implemented curriculum and the attained curriculum aimed at discovering the factors contribution to the academic achievement of students in Science, use of a method capable of making an in – depth analysis of the existing actions and reactions of the dependent variables was indispensable. For this very reason a method referred to as Field study was employed.

Statistical Population

The statistical population for this study consisted of all Second and Third High School Preparation Graders and also all High School principals and Science teachers throughout the nation. Sampling was conducted using the Multi – stage Randomized Fashion in High School Preparation institutions (i.e. only ordinary and state schools), whereupon 192 educational institutions were selected. The total number of selected students came to 7400 composed of 3718 Second Graders and 3682 Third Graders. Of the same high schools, the Science teachers numbering 182 and their principals participated in this study.

Instruments and Statistical Procedure

The data for this study were obtained using such instruments as the academic achievement tests for Science and the computerized questionnaires for High schools teachers and for schools at the Research and Planning Organization by utilizing Descriptive Statistical techniques including Distribution, Percentiles, and Means and also Inferential Statistical procedures including Chi – Square, T – test, Analysis of Variance, Kruscal wallace Test, Mann Whitney Test, Bartlett, Sample Adequacy, Regression and Factor Analysis.

Findings Summarized

High school teachers emphasized the use of Problem – Solving Technique when they were explaning their own technique. High School Science teachers, however, had no clear concept of the Problem – Solving Technique.

Of the factors relating to the academic achievement of the students, the most significant was the cultural status of their family, next in significance was the cultural status of their schools and the least in significance was their attitude to Science.

There was no significant relation between the course content taught and the course content untaught by the teachers to the Second and Third High School Preparation Graders on the one hand and their academic achievement on the other hand.

Fractals – Very Natural

Meirah Sonnenschein and Shlomo Havlin, Bar–Ilan University, Israel
Esther Bagno, Weizmann Inst. of Science, Israel
sonnenm@mail.biu.ac.il

INTRODUCTION

What is common between lightning in a winter storm, eye vessels, root systems, neural system in a human body and the structure of a bacterial colony growth on a diluted culture medium? At first glance, there is nothing in common to any of these phenomena, but if we look at the shapes mentioned, we could see that they have a similar structure – although they are from different areas of science and they have completely different length scales. All the patterns mentioned have a branched structure, with ramifications and bifurcations. Today we have the Fractal Geometry (which was developed mainly during the last twenty years) to deal with these complex shapes. This geometry enables us to investigate and characterize these patterns with simple and well–defined mathematical tools.

In the "Science 2000" project we are developing new instructional units for S.T.S. students as well as for science students in high school, dealing with "Randomness in Nature". In these units the student learn the concept of randomness with its various forms and relations with phenomena, events and shapes in nature.

The units developed in this project are interdisciplinary. They make extensive use of *advanced technologies*: computers as an inquiry lab, Internet, etc. The teaching approach is novel: The instructor serves more as a facilitator, where the learning activity is performed primarily by the student as a researcher. They give a good opportunity to use *alternative evaluation* methods by giving the students mini research tasks, which will be, performed using the models they are learning, and the computers laboratory.

The unit we would like to refer is "Fractals – Very Natural". In this unit we introduce to the students the tools from fractal geometry used to analyze and characterize the complex patterns mentioned above and others. These patterns have two common features: they are self–similar and they have a fractal dimension. During the course of learning, the student meets first the methods of calculating the integer dimension (1, 2 or 3) and then, using similar methods, he learns how to find the fractal dimension.

METHODOLOGY:

One of the most noticeable recommendations of the National Research Council (NRC) report *How People Learn (1999)* is: "Superficial coverage of all topics in a subject area must be replaced with in–depth coverage of fewer topics that allows key concepts in that discipline to be understood". The report says also, that improving student's skills can be achieved when he learns one or few disciplinary concepts more deeply. As the fractal dimension is a very basic and essential concept in our learning unit, we chose the concept of *dimension* as a key concept to be learnt in–depth.

Why is it so important to learn the concept of dimension? Because it is an underlying concept in the scientific language and in daily life. In addition, it is a very central concept in mathematics and in material sciences. Surprisingly enough, we made a literature review and found that the concept is problematic! For example, Robert Devany in his paper *Chaos in the Classroom* (Devany, 1998, pp. 97) deals with the difficulty of students to define the concept of dimension. He describes the various problematic answers given by the students to questions like: Why is a straight line a one–dimensional shape? Why is a plane a two dimensional shape and a cube a three dimensional body?

Therefore we have made a pilot study about the understanding of the concept of dimension: We discussed it with teachers, we interviewed tenth level students and checked questionnaires we gave them. We found that the concept of dimension is very obscure. When we asked, most of them could say that a chair, a table and a house are three dimensional objects, but when we discussed two or one dimensional objects or shapes, there was a lot of confusion. It was a great difficulty to define the things or to relate the correct dimension to the given objects or shapes.

In the light of our pilot study, and according to the review of literature, we developed the unit "Fractals – Very Natural" in which the concept of dimension plays a central role. In the learning unit, there is a collection of various activities, which come to support and to strengthen the understanding of the concept of dimension. The unit we developed consists of a learning book, software, movies, and in–class and outdoors activities.

A FORMATIVE EVALUATION:

A formative evaluation accompanies the development of the unit. In order to examine the understanding of the concept of dimension, we decided to adopt the Perkins's approach to "understanding" (Perkins, 1992). According to Perkins, the understanding of a concept has to be checked in learners' ability to perform various tasks, so called "understanding performances". In our formative evaluation, we found that the students who had learnt our learning unit could not perform well enough the tasks we gave them. Therefore, now, we are developing more activities, which are focussed on the difficulties we identified in the formative research.

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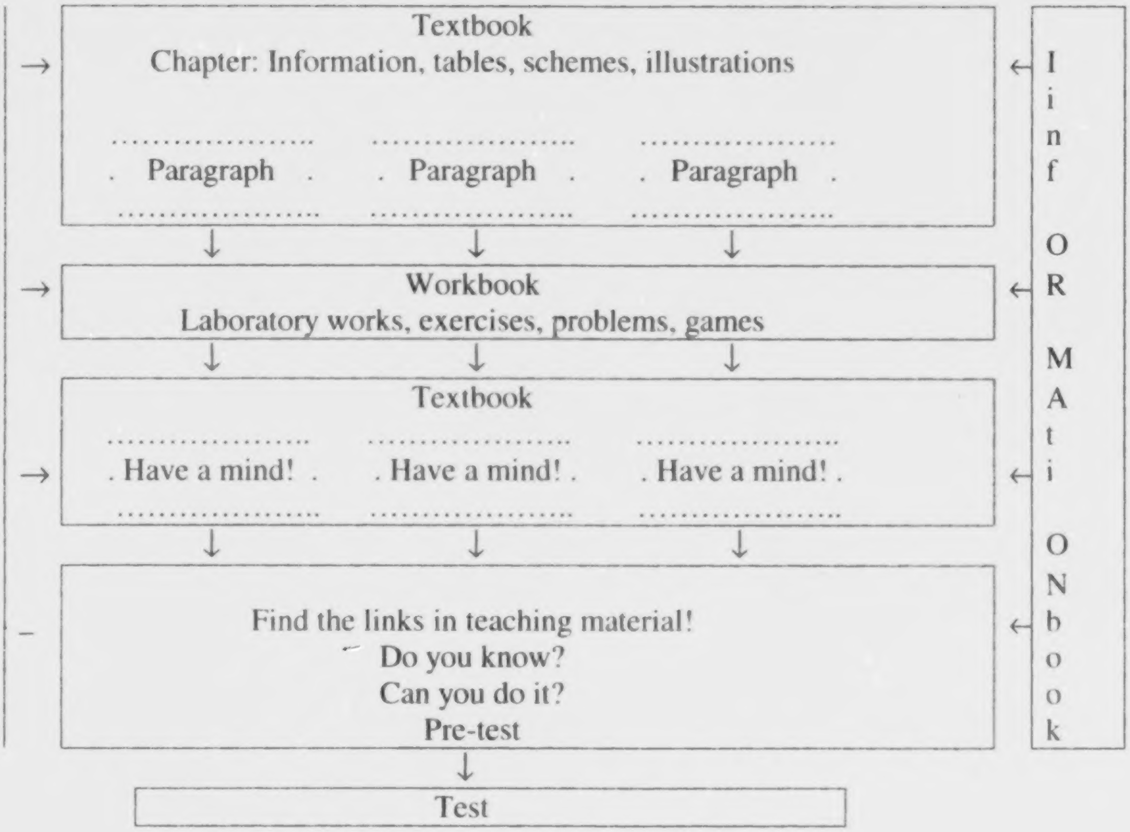
A Set of Teaching Materials for Formation of STL

Vilja Toots and Aarne Tõldsepp
Estonian Association of Chemistry Teahers,
toots@tdl.ee

The apologists of STL emphasise the need for STL supplementary teaching materials. They are convinced that one resource which can guide science education towards greater relevancy for the 21st century is the use of STL supplementary teaching materials. These materials are not extensions of the textbook, but are additional resource for the teacher to call upon as required. As such they are optional materials and can be used as and when the teacher feels it appropriate.

Not denying the role of STL supplementary teaching materials we have another approach to the formation of STL. We consider the formation of STL as a continuous process that should be realised every day and in every lesson. This is a reason why we should have a set of teaching materials supporting the formation of STL. There is in our country compiled a set of teaching materials in chemistry for grades 8 and 9. that promote the formation of STL in every lesson. This set consists of five components – a textbook, a workbook, an information book (a handbook) and tests for students and a teacher guide for teachers. The textbooks have the thematic title, present the material through storylines rather than factual text and differ by structure from other chemistry textbooks. There are special parts after each paragraph, such as "Find links in teaching material", "Do you know?", "Can you do it?" and pre–test for self-control and self–assessment. The workbook consists of different exercises, problems and didactical games societally related i.e. relevant to the students. Anyway the workbook allows the students to engage in activities relevant for the formation of STL. The information book (handbook) offers the supplementary data for generating and developing ideas and solving different problems. The teacher guide consists of supplementary material for the teachers as well as assists them by suggesting teaching strategies for achieving the objectives of learning.

The model of using the set of teaching materials in grades 8 and 9


Textbook
Chapter: Information, tables, schemes, illustrations
Paragraph
Paragraph
Paragraph
Workbook
Laboratory works, exercises, problems, games
Textbook
Have a mind!
Have a mind!
Have a mind!
Find the links in teaching material!
Do you know?
Can you do it?
Pre-test
Test
I i n f O R M A t i O N b o o k

Teaching "Microorganisms" in a STS Mode in 9th Grade

Mahmood Khalel and Reuven Lazarowitz,
Israel Institute of Technology, Technion, Haifa
mutav@edu.technion.ac.il

In the early eighties, the National Science Teachers Association (NSTA) mentioned that the new approach in science education "Science –Technology – Society" – STS, is the major aim of science education of the eighties. STS is a whole and integrated concept, which includes relationships between scientific and technological development and social activities (Yager, 1990).

The major aim of science education in the STS approach is to prepare literate citizens (NSTA, 1982; Aikenhead, 1994; Zoller, 1990; Bybee & Ben–Zvi, 1994; Yager, 1990a) among all students (Yager, 1990) through focusing on topical, interesting and important problems and issues in daily life (Bybee, 1990; Yager, 1991–2; Yager & Tamir, 1993; McGarth, 1994).

This approach could be an instrument for developing society and preparing students to their future as citizens (Yager & Hofstein, 1982) because the education interest is to take care of the student's needs in society (Bybee & Bonnstetter, 1987). Another goal of this approach is to raise the rate of involvement of students (Aikenhead, 1994; Zoller, 1990) and to encourage them to become responsible and make decisions based on values.

Science education must be updated according to society changes and societal issues which have an impact on curricula (Yager & Hofstein, 1982). The teaching of science as mediating between science and society could be effective if it includes interactions between science and society (Yager, 1984).

Since societal issues are changing frequently, the curricula must be updated continuously (Rosenthal, 1989) and there is a need to ensure that new issues are brought to the classroom learning (Yager, 1990b). Science educators should be responsible of changing and updating aims, contents and the policy through rearrangement of curricula at short periods (Bybee, 1985). It is important to constantly renewing and updating teachers and students (Pearson, 1990).

The new approach takes into consideration students' needs and societal issues. All over the world, including Israel, a new period in sciences education has began – The STS era. New curricula have been developed, aimed at elementary and middle schools. Researchers are working to develop these curricula for secondary school students, too.

A learning unit based on the STS approach has been developed, the "Microorganisms", aimed at 9th grade students. This unit includes learning tasks for individual and cooperative groups learning, with emphasis a variety of teaching and learning methods. This learning unit aims at giving students tools and skills in order to prepare them to become literate citizens in a science and technology society. It also aims at teaching biological ideas and concepts: the life unity world, the complementarity of structure and function, the basic processes which occurs in microorganisms, their role in the web life, carbon and nitrogen cycles, food industries and society health. In addition, the unit helps students to master skills for laboratory work, scientific thinking and problem solving. It encourages to develop attitudes and judgement based on knowledge and values.

This unit includes the following methods of teaching and learning: Laboratory experiments in groups, reading scientific essays, watching videos, group trips, role play games, learning in Jigsaw groups and gather information resources. In addition, the learning unit suggests an evaluation mode by portfolios written by the students.

The learning unit endeavours to rise students motivation by being practical, connected with daily life and dealing with societal issues. It enlightens the relationships between science, society, technology and the environment. The simplicity of the unit makes it possible for every pupil to master it, even if he/she does not choose biology as a major trend, since this can be the last opportunity to learn about the microorganisms which we meet everyday.

The justification for writing the "microorganisms" unit in the method of learning tasks originated from the following:

1. The mistaken idea which existing in the pupil population that microorganisms (including bacteria and fungi) are tiny and pest; in this unit the students learn about the advantages and disadvantages of microorganisms.
2. Our everyday contact with microorganisms through the: skin, respiratory system, food, drinking and everywhere.
3. Microorganisms have an important role in our life especially in food, medicine, agriculture, environment, material recycling, industries and others.
4. The microorganisms are widespread: in the air, water, everywhere, even in extreme environment conditions, heavy heat, fierce cold, high salinity, oxygen shortage and others.
5. The damage that those microorganisms can cause: old and new diseases, food poisoning, biological war and others.

The learning unit has been implemented in an Arab middle school in 9th grade. The pilot study lasted two months and the results show that students' academic achievement was higher and their attitudes toward microorganisms changed, due to the new acquired knowledge. Their attitudes related to the important role of the microorganisms in nature.

The poster will include the depiction of the learning unit, learning tasks, the instruments used for assessments and the results.

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Interdisciplinary Education in the Process of Sciences' Teaching in Romania

Fatu Sanda, Bucarest University, Romania

Russu Anca Ciolac and Cirsstoiu Jeanina, Bucarest University, Romania
tanasea@yahoo.com

The aim of this paper is to present some modalities of teaching in interdisciplinary way of themes existing in the actual curriculum (concerning Chemistry and Biology), as well as in the future curriculum (that will include the discipline "Sciences", a symbiosis of knowledge from the fields of Physics, Chemistry and Biology).

Sciences study aim to:

- observation and investigation of Nature processes which occur in the environment;
- observation and investigation of intra– and inter– physical, chemistry and biological systems;
- understanding of human activities impact upon the environment and earth, as well as influence of natural processes upon the human activities.

The teaching models were put in work in the period 1999–2000 on a sample of 500 pupils from V class, during a cycle of five lessons.

Our investigation was performed in teaching the following themes:

1) Anorganic and organic substances in nature (their recognition, characterization and differentiation)

Through experimental activities was pointed out that the entire living world has anorganic and organic composition.

2) Photosynthesis and respiration processes are indispensable for life.

Through experimental activities the pupils discovered the photosynthesis process in the green plants, as well as the microorganisms, plants and animals'

respiration. The emphasize was put on the interdependence between both processes in plants.

3) The carbon circuit in nature; the transformation of anorganic matters into organic substances and reverse.

The matters and energetical transformations issued from the carbon circuit in nature were learned by pupils by studying and building models.

4) Man's intervention into the carbon circuit in environment and nature

Concerning that theme, two topics were discussed: i) The comparison between fuel combustion and organisms "combustion" (in fact oxydation reduction process); ii) the effects of use of different fuels upon nature.

5) Pollution and environment deterioration

The carbon cycle was thoroughly studied, in order to find and establish the factors which determine cycle desequilibria and, further, environment pollution.

The didactic experiment and modelling, as knowing and investigation methods used in the teaching process, *played an important role in the methodological interdisciplinary approach of Sciences.*

In conclusion, the outcome of assessment tests administrated in classroom rendered evident the effectiveness of interdisciplinary education.

Geology Education for Future Citizens

Dobroslav Matějka, Charles University Prague,
matejka@natur.cuni.cz

INTRODUCTION

To the organising committee of the 3rd IOSTE Symposium for Central and East European Countries (Prague, Czech Republic, June 2000) no contribution concerning with the geological education was not been submitted. (As a result, projected session on geological education had to be recalled.) Also this fact probably reflects conditions in the geological education, not only in the post-communistic countries of Europe. Geological education seems to be only at a margin of interest of the science teachers as well as of the research workers investigating science education.

In contrary, geological background of citizens of the Czech Republic (CR) is rather low to negligible. In one of parts of the TV contest "Do you want to become a milionaire?" being organised now in the Czech Republic as well, any of nine participants (of various age) was not be able to answer the question: "Order the geologic eras after their chronology: Archaean, Proterozoic, Palaeozoic, Mesozoic." Although in Czech these term are slightly confused, that can be shown as an indicator of the geological literacy in the CR.

EDUCATION IN GEOLOGY IN THE CZECH REPUBLIC – PRE-MORTAL STAGE?

In the Czech Republic, geology as a subject in secondary education is nearly agonised now.

Here, in 1984 geology was omitted from the curriculum of the upper secondary education. There were several causes for such a deep decision. As geology had been before taught as a part of the subject Biology and geology, large expansion of biological education was the first of those causes. On the other hand, decreasing interest in mineral resources and strategic raw–materials played their role as well.

Since that time, geology has never been re-established. (Objectively, a small part of geology has survived in the Geography as physical geography. It is only geology oriented to show principles of plate tectonics and to present endogenous as well as exogenous processes as forming the Earth's surface. Similar situation in Poland is shown in Cichy, 2000.) Even, the schools with extended science education have not kept an obligatory course of geology. Only a facultative one is now possible, however, that uses not be commonly supported by the school–masters. Moreover, teachers having good qualification for geology teaching are only rare.

In such joyless conditions, highest attention should be paid to the education in geology (more properly in fundamentals of geological sciences) in the lower secondary education curriculum. Unfortunately, it is not so. In the lower level of secondary school (11–15 y.), geology is taught (by teachers of biology) in one of two last years (8th or 9th class). However, in the last time it has been strongly suppressed in favour of another topics. Reduced geological curriculum became inevitably unsuitable, because of it does not enable to present geological sciences as a whole.

Another problem can be seen in the so-called ecologisation of natural science in the lower level of secondary school, promoting in the last time. It is based on a special curriculum of the subject Ecological Science reducing geology to an minimal extent.

As shown, apart from the school leaving age, the level of geological literacy of our citizens is very low. Generally they exhibit some guidance in common plants and animals but not in the "abiotic nature". Students completing full secondary school are over–educated in biology or geography but they do not know what they have under teir feets. Then, in the pre-school and out–of–school education of their children a very important factor is lost – the transfer of basic geological information (most common minerals, rocks, fossils or geological phenomena) from the parents to the child. That is a significant difference as compared with another parts of science (botany, zoology and human biology) creating a considerable handicap for school children. In the school, the first introduction to the "unanimated nature" is given at age of 9 years (4th class). However, following four years are quite geology–free. Afterwards, around twenty five minerals and twenty rocks as well as some fossils are brought in the 9th class what reminds of a shock therapy for pupils. Most of them so become discouraged and lose any interest in geology once for all. Later, they can not stimulate their children to be interested also in abiotic nature, and the cycle has been closed.

SCIENCE TEACHER EDUCATION – PRESENT POSSIBILITIES

Thus, the pivotal mission of teachers of science in the field of geology is quite obvious. How are the teachers prepared and how are their possibilities to perform it?

In the lower level of secondary school (11–15 y.), geology is in the last year (9th class), as a part of the subject Science included in 6th – 9th classes. 6 hours are the minimum allocated time for Science for all four years. This allocation is usually distributed by a school in such a way, that in the 9th class, where geology is taught, Science has only 1 hour in a week. In excess, there is a lack of teachers having good qualification for geology teaching.

Science (and its part geology) is taught by teachers of biology. Of course, the teacher students of biology are influenced by the child – school – parent – child cycle mentioned above as well. Therefore, it is necessary to start their education in geology from the zero level. Some better situation is in pedagogical faculties, preparing teachers for secondary schools. The students must pass through several courses of geological disciplines there, so, there is more time to present large volumes of teaching material step by step.

However, on the faculties of science, conditions are worse, because of they prepare the teachers for upper secondary level, where geology is not obligatory. As a result, in their plans of science teachers training geology has only a marginal position. In the Charles University Prague, Faculty of Science, only the short basic course of geology occurs, divided to Mineralogy & Petrology and Geology & Palaeontology (in 7th and 8th semester, respectively, 4 hours in a week, 1 hour = 45 minutes). Now, as the European Credit Transfer System (ECTS) has been introduced, this course will be reduced to 75 %! It is very difficult for students to accept all geology in such a short time and nearly excluded to master it. In such conditions, graduates of teacher study cannot be fully qualified for geology teaching as they find their job in the lower level of secondary school. Consequently, they avoid of teaching it or reduce it to minimum, contributing successfully to the negative activity of the cycle mentioned above.

SPECIALIZED TEACHERS FOR GEOLOGY EDUCATION!

Therefore, in 1993/94 academic year self–standing pre–service teacher education in geology on Charles University, Faculty of Science, has been started (combined with biology; with chemistry not realised yet, with physical education starting in 2001/2002 in the Faculty of the Physical Education and Sports). These specialised teachers are believed to find their jobs in the upper level secondary schools and to help to re–establish geology to its original position, although by the way of facultative course as yet.

This idea is not new, specialised teacher study in geology had already existed in history but it was broken for twenty years. It must be also mentioned here, there is teachers study in geology in other faculties of science in the Czech Republic but geology is a part of a triad with another two subject there. We determinate to establish a double–combination, not only to adapt the geological part of study to the biological and chemical ones being already in progress in the Faculty of Science, but in the first place

- to yield a sufficient time range to present geology to our students in all its complexity, and
- to have a time reserved for integrating of progressive trends in geology into education of our students.

GEOLOGY FOR ENVIRONMENT: REFLECTION IN EDUCATION

In the last years the goals of geology has been changed considerably, tending to solve the environmental problems. It does not mean not only traditional objectives as removing of results of mining but also exploration of risks as contamination of water and soils, air–pollution as well as waste managing etc. Environmental geology is a newly formed geological discipline. Of course, all that must be reflected in the teacher training process and consequently transferred to the science education in the secondary school. Certainly, that is a good idea as ecology and environmental education are strongly forced in the curricula. However, the problems of environment are commonly reduced to human–plants–animals relationships, reflecting air, water and soils. The solid Earth as a topic is more is treated nearly separately and reduced more and more, in the Ecological Science is it quite marginal.

Instead, a complex approach should be applied. At least, because of "the world is not made up of separate, isolated components – rock, soil, sediments, water, air and organisms. Instead, these components have evolved interactively in the course of our planet's 4.6 billion–year history, forming inseparable parts of the Earth's biophysical system" (Murck et al. 1996).

So, to show to the pupils the environment in all its complexity, the system solid Earth – hydrosphere – atmosphere – biosphere must be presented. Of course, that should be the common goal of all natural sciences.

Geology can be used as an excellent tool to understand the human environment. However, to do it, it must be well understand by citizens. So, it must get its chance in the secondary school curriculum. Within it, as another natural sciences, geology should be presented in all its complexity, starting with minerals as the keys to rocks, that are the ones to know how our planet works. Only learning it we can understand "the human–planet relationship – how Earth processes influence human lives on a daily basis, and how human actions, in turn, alter the functioning of Earth systems" (Murck et al. 1996).

The sense of geological education can be illustrated as like this: There is now a time of ecological conflicts between citizens initiatives and state or firms and corporations. It is often difficult to orientate oneself in such a case, and citizen's knowledge of geology can help here. So the case of the nuclear power–station Temel_n being activated now, because of that is the Czech Republic in controversy with Austria, must be seen in wide context. It is argued by the energetic corporation, as the power–station placed in service, the coal power–plants damaging environment in the northern Bohemia will be progressively discarded. In opposite, in these power–plants desulphuration equipments were recently installed, so their functioning is more ecological now and can be further operated instead of the Temel_n nuclear power–station. However, desulfuration needs enormous quantities of pure limestone taken in a huge quarry located in a protected landscape area (Bohemian karst) and invading a Palaeozoic coral reef – an improtant paleontologic locality. Moreover, brown coal burned enormously in cauldrons of power–plants contains is extremely rich in various trace elements. Now toxic at burning, it can be used much more effectively in future!

It is necessary to present geology as a science of our own environment. Not focused only to global environment but also observing our close surroundings. A brief case study can suggest that a lack of basic geological knowledge is able to have unlovely consequences. It is dealing with the hardness of minerals, i.e. with one of principal properties of minerals.

A SMALL CASE STUDY: HARDNESS OF MINERALS – THEORY AND… PRAXIS?

Hardness (H) is a distinctive property of minerals. Each mineral, as briefly described in handbooks of systematic mineralogy, is always characterised by its hardness (next to chemical formula, class of the crystal symmetry and physical properties as density). To recognise the hardness of a mineral, the Mohs' hardness scale has been used. As widely known, it is relative 10 step scale, where each step is represented by a mineral. Such minerals were chosen into the scale that are commonly or nearly commonly found on the Earth surface. Of course, three most frequent – quartz, feldspar and calcite – are included. The Mohs' scale is known notoriously and we can find it in all the textbooks of geology in the low secondary education. It is commonly memorised. (The students of biology education asked after seven year break of mineralogy have been often able to reproduce it right.)

Low level of secondary education (in 9th class in the CR): To present and memorise the scale, to show their minerals (as possible) or some of them, to inform (if appropriate to demonstrate) that minerals with $H \geq 6$ scratch the glass, minerals with $H \leq 5$ can be scratched by a pocket knife, and soft minerals having $H \leq 2$ can be scratched by a fingernail. Practical result: The pupils can distinguish the minerals after hardness. Moreover, they become aware of natural materials having distinctive hardness, i.e. distinctive mechanical properties.

Upper level of secondary education (e.g. gymnasium in the CR): Extending of basic knowledge about hardness: The Mohs' scale is relative. As compared with absolute hardness of their minerals it can be shown the scale is not linear. Differences in absolute hardness between neighbouring members of the scale are generally higher as the relative hardness rises and are increasing nearly exponentially.

Practical result: The mechanical properties of stony materials can be strongly distinctive. The use of such materials must be carefully considered.

The disturbing influence of (pseudo)ecologisation: It is recommended by Dr. Kvasničková, main author of concept of the "Ecological Science" not to memorise the physical properties of minerals but to use them in praxis. The hardness scale is presented as an example of that dubious strategy (Kvasničková 1999). How to use the hardness scale without knowing it? How to recognise the minerals without knowing their typical physical properties? No comments more!

Negative influence of long time distance from the basic information, moreover, not repeated on a higher education level: Ignorance of differences in mechanical properties of minerals and rocks.

Possible consequence for human own environment: Use of mechanically inadequate stony materials.

The pavements in Prague have been built traditionally as a mosaic of light and dark stony cubes alternating in simple motives and using white and black limestones. Recently, the light parts of pavements have been still compounded of limestones or marbles, being composed of calcite with H = 3. However, for the dark ones has been used a granodiorite – rock consisting mainly of feldspar and quartz having H = 6 and 7, respectively. Accordingly, after some years the light parts of pavements will become more eroded by walking as the dark ones, i.e. the originally flat pavement will change to a system of light depressions and dark elevations. As a result of low geological literacy of competent agents of the town council as well as of the firm building the pavements. Good walking, citizen!

WHAT TO SAY AS A CONCLUSION?

The teachers educated in our specialised study should bring their students on understanding that rocks and minerals (and fissils, of course) represent an integral part of nature as plants and animals. They are a key to understanding of geological processes. To know the functioning of them means to know how our planet works. Geological processes affected and affect plants, animals as well as human inhabitants of the Earth. On the contrary, in exploiting mineral resources, managing the Earth's surface or changing natural biochemical cycles we become a part of the geologic cycle.

Such a "geological" point of view should help to future citizens to protect their environment in its full scope.

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The Effects of Islamic Culture on the Development of Science and Technology

Hossain Attar, Islamic Azad Univ., Tehran Center
atrhosen@ Mltavista.com

At the present era, it is belived that science in all fields have had its most progress in the last quarter of the twentieth century. The peak of this progress was aimed at creating new ideas or looking at the old problems from a new angle by the inventors. Therefore it can be said that technology is a product of science and moving power of development.

In this respect the innovators started to apply the new thougths and ideas for solving the real life problems, in order to reflect the societies, science and technology fundementals.

In this regard and based on the Islamic recommendations on the development of education and educating, development of science must be institionalized. The requirements for carrying out this mission is to consider the scientific policies.

Achieving the scientific policies is probable through the following three stages:

- Making policies
- Planning
- Implementation

Islam as a comprehensive and strategic religion, that presents many alternatives for the development and institutionalization of science which will be brought in the main article.

In the Islamic thougt, it is believed that wisdom is one of the greatest gifts of the Allah to human being for him to gain scientific knowledge.

The Allah has vested the wisdom on the man kind and this is how the human beings uprior creature.In the Islamic thougt thinking is considered as the major factor for was made the growth and self actulization of the human being in the society.

No one gift as wisdom and the power of thinking is worth and could be compared with any other critical humane value. The role of thinking and its out comes that are science, knowledge and improvements in human life, happiness, and evolutionalizing in facing problem can not be compred with any other of human forces.

All over of our religious sources either Quoran or religious passages are many indications of gainning and developing science and knowledge and the hardship that one must bear through it.

A few examples are followed.

In the first sect of the Quoran, the creation, Assah has told Mohammad the prophit peace on him, about science and knowledge and the important role of those in Islam. professor Tabatabae in his book has written about the creation sect:

"He who has thougt the mankind. Allah tought the human being how to write and through this he learned about scientific knowledg".

In this article it will be tried to base the refrences from theological sources in order to achieve Islamic pattern that one can be committed to his religion while enjoying modern thechnology in his life.

With aglance at Islamic civilization it can concluded that there have been many great theorecians , innovators, thinkers, philosophers, historians in Islam and some of them have successfully brought the Islamic civilization to its peak and glory. At the present period it is believed that science in all fields have reached its most improvement in the last quarter of this cenury.

Science and Physics Textbooks and the Conceptions of Pupils about Sciences

Liliana Ciascai, “Babes – Bolyai” University, Romania
Luminița Chicinaș, County School Inspectorate of Cluj, Romania
Adina Maria Pop “Babes – Bolyai” University, Romania
lchicinas@personal.ro

I. TEXTBOOKS AND EDUCATIONAL REFORM IN ROMANIA

During the 1990s, the field of education has faced the challenge of improving the quality of the services it provides to all kind of learners. Thus, in Romania, the new Educational Law (1997), together with the other rules and normative emphasizes the importance and the increasing role of in– service training of teachers in order to built new democratic, autonomous schools. Central to carrying out these requirements is the state' capacity to work with local adult education programs in providing training on new teaching methods and attitudes, in motivating programs to consider the adoption and the development of new practices, and in promoting the role of adult education in the work force development and human services delivery system.

The educational reform started since 1997 in our country focused on the following main problems:

i. systemic changes in the school management

⇒ new approach of school' management (school as educational services provider accordingly to the community needs and interests)

⇒ schools' inspection (as support for improving school performance and development without the straight control before '89)

⇒ the education quality (quality indicators and criteria built in order to improve school ethos and results)

ii. facilitating professional development

⇒ in– service training for teachers, head– teachers and inspectors

iii. new curricular approach which ensure the pupil centered teaching and learning

⇒ five curricular areas: *Language and communication* (Matern and Modern languages), Mathematics and Sciences (Mathematics, Physics, Chemistry, Biology), *Man and Society* (History, Philosophy, Psychology, Economics, Religion, Civics), *Arts and*

Technologies (Sports, Painting, Music, Technological Education) and *Counseling*

iv. new approach of pupil and schools assessment and evaluation

⇒ new design of K– 8 and K– 12 national examinations

⇒ new structure of academic year (2 evaluation period of time, each during 3 weeks at the end of each semester)

As a consequence of changes induced by the above approaches, an challenging educational project aimed to implement the educational reform in the schools in our country have been designed by representatives of County School Inspectorate, Teachers Training Department of "Babes – Bolyai" University and Teachers' House from four counties. This project has six main program lines: *School improvement, School and community, Inter-institutional communication, Pre-service and In– service training of student teachers, respectively of teachers, Development of educational support for pupils from gipsy communities and Public information* and started in the 1999–2000 academic year with a contest of the best school projects produced by the schools in each county. In– service training is a main component of educational reform as well as of the "Reform School" project – the name of our county's project, so we stated the following aims: *to build a learning community for the science teachers in our town in order to improve their teaching strategies and to help them to cop with the challenges of the new educational reform in Romania.*

While it is true that there are teachers whose attitudes are positive towards the promotion of good science teaching – learning situations, the reality of schools still consists of lessons where their teachers transmit science, at best, as a set of facts, laws and data. The results brought by physics education researchers' pedagogical experiments have good consequences only when rooted within the school as an institution (teacher, curriculum and defined pedagogical practices) and within a particular context (culture, program, country). We conclude that there are no universal methods to modify this situation, that is, there are a variety of sciences teaching styles as a result of the strong interaction between teaching attitudes and competencies, school and society, as suggested by the diagram shown below. (Fig.1 Model)

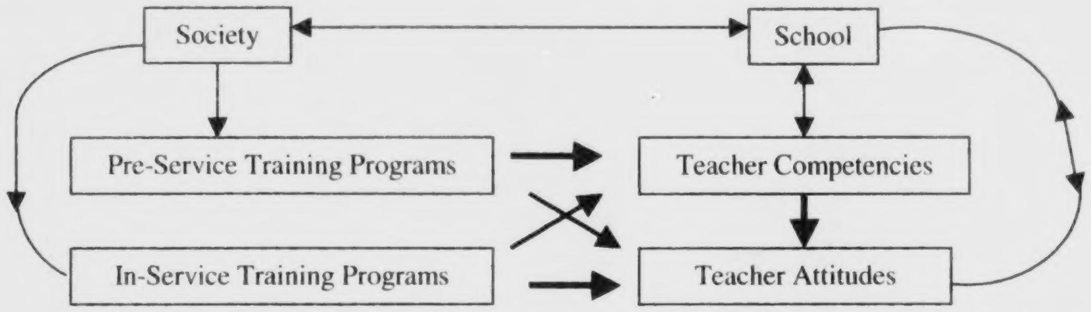

Fig. 1. Model

Also, since 1995 academic year, in the primary school, the unique textbook for each subject has been replaced with an offer of three different textbooks for each teaching subject, so called alternativelly textbooks. From 1996, the seccondary and upper secondary school textbooks have been also replaced with new alternatively textbooks, on the same system: three textbooks for each teaching subject, the teacher choosing the textbook that is most reliable to his/her classes.

II. SELECTED CONCEPTIONS FROM ROMANIAN TEXTBOOKS

a) Conceptions about light The model "light bath" is mentioned by E. Guesne (1986, p. 137), C. Prot (1989, p.6), W. Kaminski (1989, p. 974) and it states that "we are seeing the objects in a room because there is light all over the room" and we are not seeing the same objects because there is no light (fig. 2). Persons which have this conception also think that there is no link between the object – the light spread by the object – and the eye (fig. 3). The model "light bath" is a static model of light and promote an interpretation of the shadow as absence of light: e.g. behind the notebook "there is no light" or "it is less light".

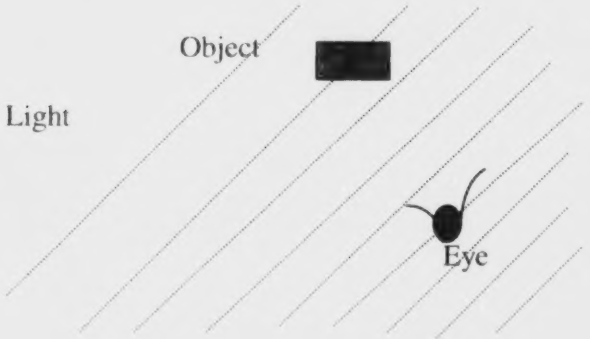

Fig. 2

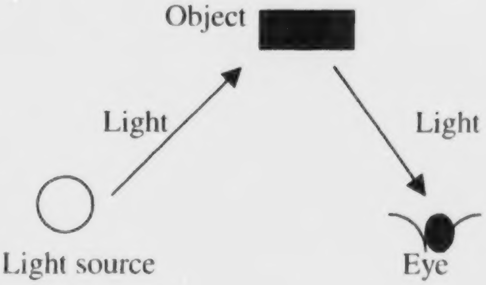

Fig. 3

It must be noticed that, when the object (e.g. notebook) is on the table some pupils believe that the shadow of that object remains under it. (G. de Vecchi, A. Giordani, 1996, p.74).

Other partially models of light and seeing were identified and described by E. Guesne (1986, p.139) and C. Prot (1989, p. 107–111). Neglecting the holistic perspective mentioned above has as consequence the following clichés that incorporate explanations for respectively physics facts. Thus, there are pupils which still believe that we are seeing an object because there is light in that room (fig.4) or because we are looking at it and there is light (fig.4a) or because there is light over it and we are looking at it (fig. 4b) or because there is diffusing light, respectively (fig.5) but without mentioning that diffused light must reach the observer's eye.

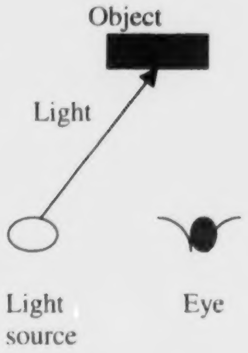

Fig. 4

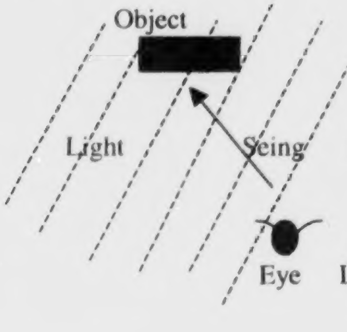

Fig. 4a

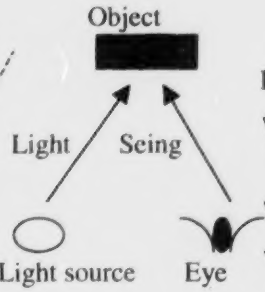

Fig.4b

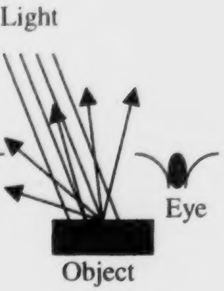

Fig. 5

Light seen from one side (W. Kaminski, 1989, p.974) In the specific case of a light reflection experiment the light seen on the Hartl disk or on a white screen is identified with the incident beam or reflected beam even they represent in fact lightly objects which diffuse light in all directions around.

Materialization of "ray of light" model Pupils learn about light's propagation (including light' speed) from very first lessons in optics. Unfortunately, the physics literature in schools, especially for first grades of studying physics (VI– th grade, 12 years old) include the following description : "we represent a very thin light beam by means of a straight line called light ray". This model, (without mentioning the fact that the light ray does not represent a physic aspect of light phenomenon, but only an abstract notion / concept) is used often by the pupils. Even latter time, after studying deeply optics, this representation is still active. May be a reason is that this model is very often used in school textbooks in order to explain the image' formation in lens / mirrors or systems of lens and mirrors. This model that imply also dividing the object into points (from which "light rays" are constructed) and also dividing the lens into points (points where the light interact with the lens) conduct to wrong (erroneous) predictions in situations when the lens' surface is partially covered in the interaction points of the "light ray" with the lens. (W. Kaminski, 1989, p.174).

b) Conceptions about electric current

The model of antagonistic currents (apud J.L. Closset, 1989, p.933) emphasizes a conception with very long life in the history of physics. Ampere believed that "there is a double current, one with positive electricity and an other with negative electricity, starting in opposite senses form the points where acts the electromotive action an getting back together in the opposite point of the circuit" This conception named *"the model of antagonistic currents"* is present also at the primary school pupils who justify by means of this conception the need of two conducting wires used in order to connect a consumer at a generator (network). Our study emphasizes the presence of this conception at Romanian pupils from third and fourth grades.

Compulsory connection at a "+" end and at a "–" end In order to light a bulb in a serial circuit feed with two batteries with different electromotive tensions, the bulb must be connected compulsory at the "+" end of the first battery and at the "–" end of the second battery. If the bulb is connected only at "+" or "–" ends of different batteries, then the bulb will not light at all (A. Bensenghir, J. L. Closset, 1993, p.16).

Current' consumer: a circuit element (resistance, bulb, electric heater etc) called "consumer" is, due to the usual language, considered implicitly electric current' consumer. The electric current is considered by a lot of pupils having the liquid' characteristics, as well as an energetically aspect (s. Joshua, J. J. Dupin, 1987, p.217). By considering these reasons the two identical ampermeters will measure different electric current intensities in front and behind that consumer.

The resistance opposes at electric current flowing If the circuit element will be a resistance, than, again the electric current will have a smaller electric intensity behind the resistance than in front of it. This behavior is motivated by the fact that the electric current must overpass the resistance opposed by the element of circuit. As the resistance will be increased the difference will be greater.

The sequential reasoning In both situations described above it is a reasoning in electric current terms and the electric circuit is not considered as a system but as a route when any change made for a sequence of the circuit influences only the circuit in front and not the circuit behind that sequence. This explanatory model is called by J. L. Closset (1989, p.940) as sequential reasoning.

The hydrodynamics analogy The explaining models described above are usually accompanied by the idea that the electric generator produces electric current having a given intensity of electric current (which is a characteristic of the circuit) and that the intensity of the produced electric current will be the same even the configuration of the circuit will be changed.

c) Conceptions concerning the relationship between heat and temperature The caloric We find that pupils have a model of "materialization" of the heat which remember us a conception encountered also in the history of physics: the caloric (as being an elastic fluid which embedded all bodies and which can not be detected nor when the bodies were at thermal equilibrium neither during the thermal process because it was transferred to an other body or to the surrounding medium). This transfer has been considered as a cause of the temperature variations suffered by the body and in this sense the temperature is a measure of heat exchange. This model might be caused by the difficulty of pupils to accept the constancy of temperature during a state change, when the system is still heated (difficulty mentioned by G.de Vecchi, A. Giordan, 1996, p. 116)

d) Conceptions in mechanics field The relation mass – gravity As long as more air is pumped in a ball it became easier. *The disappearing gravity attraction* A book putted on a table is not falling down because the gravitational attraction disappears. The gravity attraction (gravity of a body) is decreasing when a car pass on a curved bridge or when the body is surrounded by water. *The principle action – reaction The normal* *reaction* (the force exerted by a support on the studied body) and the gravity (defined as the force with which the Earth is acting on the body) were described as action – reaction peer. (j. Galli, 1995, p.2 21). The friction force (kinetic or static) as peer force, identification of body ' s gravity (defined as above) with the deformation force (for an elastic resort, in equilibrium and with neglected mass) (I. Viennot, 1989, p. 962 – 963), A. Gibaud, M. Hemi, 1996, p. 1467).

e) Conceptions concerning digestion and respiration In literature there are mentioned some levels of explaining these phenomena (G. de Vecchi, A. Giordan, 1996, p. 30–32). We correlate these information with our observations. *We are respiring only at the lambs level* Concerning the respiration we found that pupils from third to fourth grades reduce the respiration at the nose – mouth level "the air enters on the nose and goes out from the mouth", or, at the lambs level. In order to explain the lambs functioning, the same pupils use the following cause – effect relation: "the air is aspired inside of lambs which are increasing their volume and when the air is expired the lambs' volume decreases". *The digestive system as a pipe* The digestive tube is draw by the pupils as a simple pipe line which ended suddenly or which has two exits one for sold residues and an other one for liquid ones alone. Sometime a kind of stomach is situated on this pipe, which might be the ending point of the digestive tube. Generally, there is no differentiation of other components of digestive system.

III. TEXTBOOKS' STUDY

We started our analyzes from the attitude of teachers from countries where there have been conducted and published studies about conceptions and consequently the teachers know these points of view. The teachers' attitudes in the mentioned countries might be:

√ Ignoring the conception "our pupils can't have such ideas";

√ Avoiding conceptions by a didactical approach of content to be taught while "there is a risqué to fix conceptions"

√ Stating the importance of knowing conceptions. This knowledge of conceptions is necessary from different reasons starting with "the conceptions are useful in order to motivate the pupils" and going to "the existence of a conception obliged us to build an objective centered on the overcoming obstacle and continuously models the teaching approach"

√ Knowledge of conceptions allow introducing of them as erroneous answers in items with many answers variants.

Studying the Romanian textbooks we tried to identify:

⇒ Conceptions mentioned in literature in different countries and which could be found in the actually Romanian textbooks

⇒ Teaching approaches which ignores the existences of conceptions

⇒ Teaching approaches which includes the conceptions into the assessment items (as erroneous answers to a question problem).

By a carefully analyze of lesson's scientific content we tried to establish if the textbooks authors were aware of the existence of a conception and consequently if they propose a teaching approach in order to avoid the conception strengthen it, or the authors consider the conception a typically error. For this last case we didn't make any assumptions.

The studied textbooks were:

School type	Teaching subject	Grade	Number of textbooks studied
Primary	Sciences	III - 10 years	1
	Sciences	IV	1
Secondary	Physics	VI	3
	Physics	VII	3
	Physics	VIII	3
Upper Secondary	Physics	IX	10
	Physics	X	20
	Physics	XI	1
	Total of textbooks		42

Observation: In order to consider a teaching approach as a way of preventing the installing of a conception we considered that that teaching approach must also offer the scientific accurate explaining model. In order to consider that the textbook help without the accurate scientific knowledge the textbook must propose learning activities (including assessment items) which should oblige the pupils to call back the conception and use it.

IV. CONCLUSIONS

Our results show that the Romanian authors of science and physics textbooks either ignore the existence of conceptions (their own or pupils' conceptions), or don't know the treatment of conceptions. For this late case they consider that the overcoming of a conception suppose only to oppose the conception with the accurate knowledge. We aimed to realize a diagnosis on the Romanian textbooks' quality from the point of view of helping students and teachers to overcome their conceptions, the approach of conceptions and consequently to make them aware about the existence of conceptions and help them to write high quality textbooks.

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Environmental Issues, Including Sustainable Development and a Culture of Peace

Science and Technology Education – Shaping the Environment of the Future

Rosanne W. Fortner, The Ohio State University, USA,
fortner.2@osu.edu

It is a sign of great foresight and wisdom that led the IOSTE conference organizers to include a sub-theme about Environmental Issues in a conference on Science and Technology Education. While the subject area stands out as very different from the other sub-themes, a bit of thought is all that is required to see the connections. The environment is being shaped each day by human understanding (or misunderstanding) of science, by applications of technology (or mis–applications), and by the way young people are taught to connect, apply, and deal with the effects of that science and technology.

As educators, our responsibility is to help learners prepare for their future, and in so doing we configure our own future as well. Science is the fastest changing curriculum area for schools. A test we develop today to evaluate student knowledge of science may be obsolete tomorrow as we learn more, connect more disciplines, and examine the subtle ways that our understanding of science is changing. The textbook in that heavy student backpack today is lacking in current data and insights; its examples are global but students have no tools for seeing local applications of them. The Internet as a curriculum supplement provides much science information, but we lack effective ways of selecting materials and using that resource. Internet technology seems somehow separate from our realities, and while it has potential to connect us for conversation worldwide, it may divide our cultures because of inequality of information access.

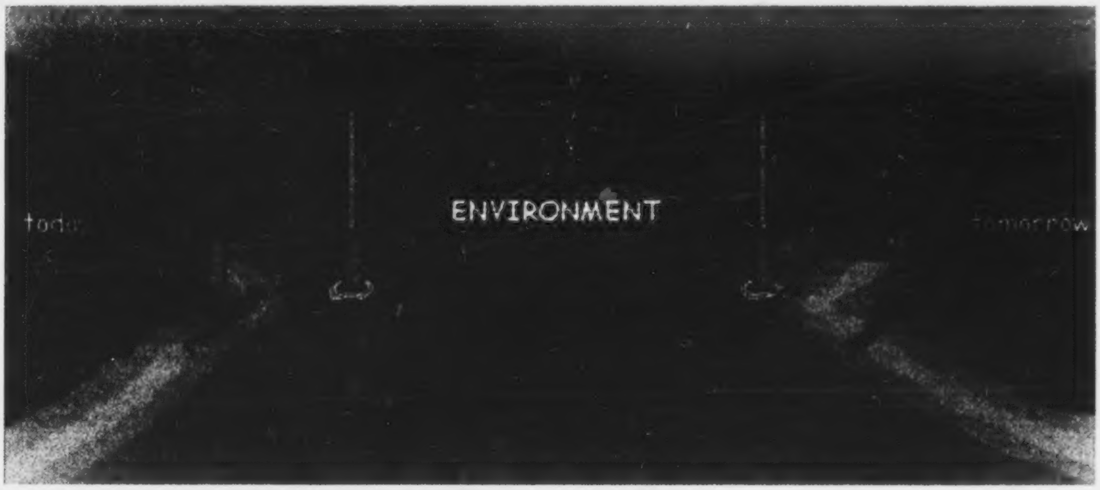
In the world outside the classroom, it is technology that is the fastest changing aspect of life. There is mounting evidence that our goal is to make our communication technologies faster, better, and more compact (a Watchman, pocket–size cellular phone, microsurgery). For other technologies, faster, better and larger size may be the goal (the Concord, the supercollider, the Ford Expedition). Technology goals in the U.S. drive research in universities and industry, and therefore they restrict attention to certain types of development, starving other deserving research for the lack of funds. Ohio State designated all its discretionary research funds this year to study biotechnology, nanotechnology, and information technology. Apparently no one saw the value of looking at big picture research that might involve ecosystems, atmospheric changes, and long–term trends in species loss.

What will we discover when we do decide to look at the big picture of the environment? Speedy development is not always accompanied by foresight. We build, then we assess. In the process we have embarked on what could be some interesting one-time experiments! When we discover what effects our technological progress has brought, will there be time to avert the impacts? Can the Mediterranean survive the changes brought by the introduced *Caulerpa* seaweed; will atmospheric changes bring us a greenhouse or an ice age; will future wars be fought over water supplies? What kind of environment are we shaping for the children to inherit?

The time has come to use our science and technology, through deliberate and well-planned education, to assure that the future we are building is one that is sustainable and peaceful. The tools to do that are available, but the motivation to use them has been lacking. Teachers are charged with the task of educating the next generation, so changes in schools may be the key to changes in the environment.

How does the environment relate to the IOSTE conference components?

Imagine the parts of the conference as pieces of a bridge that is being built. The bridge is the Environment, and it connects us in Today's world to those who will inherit Tomorrow's world. Before the span can be erected, it must have strong support, provided here by the sub-themes.



- **Resources for instruction**. While textbooks have their place in instruction, they must not be the only resource used. Lectures and reading are shown to result in students learning only about 30% of what is presented. "I hear and I forget. I see and I remember. I do and I understand!" These words have been a motivation for science educators around the world for many years. The words mean that far greater amounts of time must be spent *doing* science, experiencing the interconnections of the Earth system, constructing learning by manipulating tools and evaluating cause–and–effect. The student who can answer all the TIMSS questions correctly but believes the beach litter comes only from the sea has not been adequately prepared for the environmental future.

- **Relevant teaching**. Because of the reliance on textbooks, often produced in other areas and trying to tell everything in a small space, many students have trouble relating global ideas to what they see around them. Schools should make use of the people, places, and things near the school for their instructional potential. There is no cost for bringing in guests from the community, walking around the school yard to collect environmental measurements, or assembling data on local changes over time. There is a large cost to *not* doing so, as students lose connection to their environment while they gain access to whoever will call them on their cell phones and instant messagers. Schools need curriculum *activities* that encourage local learning, and assessment needs to look at more than recitation of exact answers. Local projects offer much for relevant learning, but even everyday classroom interactions with small groups of students will assist learners in becoming cooperators in their own education.
- **Research** has been done on many of the aspects of education we seek to try. Professional journals provide activities and assessment ideas, and the research articles can offer much to the practicing teacher. As in the world at large, where "those who do not know history are condemned to repeat it", educators who do not expand their own learning through professional readings and courses may get through the school day but they never contribute to the growth of their discipline. Improvement of education requires that instructional leaders (teachers) become lifelong learners themselves. Not only does this improve the classroom, but it also renews teacher enthusiasm and contributes to positive role modeling. Both theoretical and applied action research are needed for our growth.

Thus we lay the bridge of environment across these important pillars, and it reaches from today to tomorrow. Then we build its superstructure to have even greater strength: the towers are the science and technology that can either serve the environment or threaten its integrity. To make those towers as powerful as possible requires more of that lifelong learning. Teachers need to know not only their own science discipline, but the full fabric of interdisciplinary sciences. Too many facts? If that is how science is being learned, of course adding disciplinary knowledge will add too many facts. Science instead needs to be studied as a system, with processes common to all disciplines and connections that cannot be ignored.

How important are environmental issues to teachers and students?

Research from many countries supports the idea that teachers and students value the environment and want to protect it. For example the specific issues tested among Cyprus teachers of secondary science are shown in Figure 1. A total of 110 useable responses were returned from the population of 167 natural science teachers, for a response rate of 61%. The respondents included 53 males and 44 females, with an average of 18 years' teaching experience. Bars show the teachers' responses to (a) How important is the issue for students in your school to know about? (b) How much do you know about the topic? (c) How much do you teach about the topic?

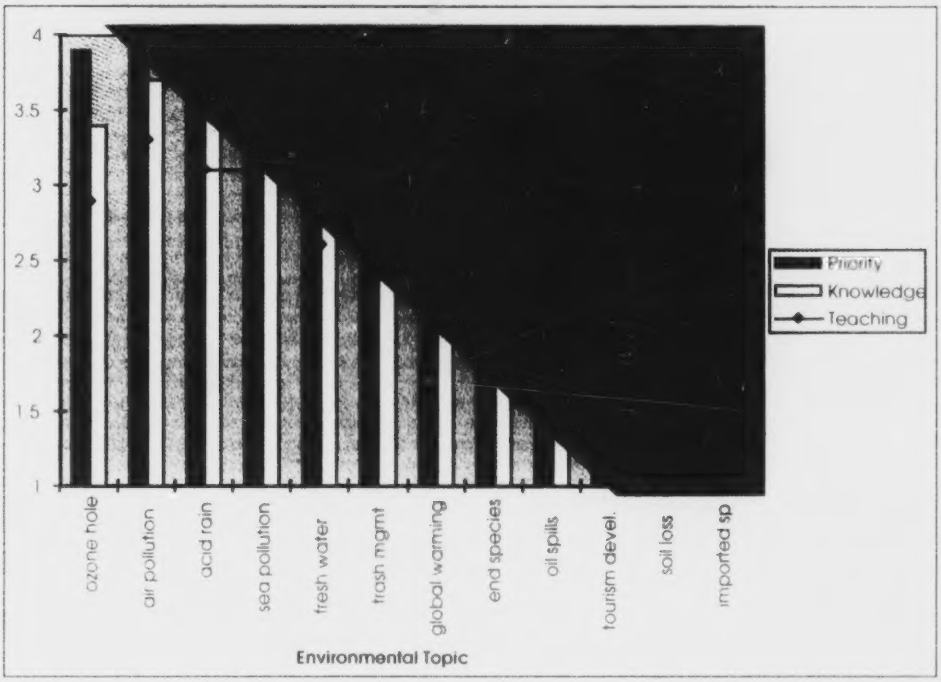


Fig. 1. Teacher Priorities, knowledge and Teaching of Environment Topics.

Similar questions are being posed to preservice teachers and to Lyceum students for comparison across the generations. What does the information do for our education planning? In this early analysis it appears that some critical subject matter may not be reaching students in Cyprus. Imported species are common on the island, and though some may have negative impacts there is no agricultural inspection at Customs, and people routinely bring favorite plants from other countries for cultivation in Cyprus.

Fresh water availability is a serious issue for the country. Water for city homes may be rationed in drier seasons. It appears that the concept of consumptive versus nonconsumptive uses of water is not being taught. Agriculture (a consumptive use that pulls water out of the hydrologic cycle for long periods) claims 78% of the island's water use, and the popular citrus and peanuts (non-native crops) are the biggest consumers. Combining the science of hydrological processes with the social applications of water and conservation would provide excellent instructional opportunities for data analysis and decision–making. Since water management in Cyprus relies on reservoirs, desalination, and some recycling of waste water, incorporation of these technologies into discussions in science classes would use local resources, make the learning relevant, and offer students the opportunity to develop research skills in a real–world context. The environmental bridge would be built for that topic.

In the U.S. many sections of the country are water–rich, and research has focused on how teachers use that resource to make their instruction locally relevant. A study in the Great Lakes region found that teachers ranked the priority for water issues as 1) water quality, 2) personal responsibility for the environment, 3) toxic chemicals, and 4) water uses and conservation. They indicate a wide range of knowledge about the 22 topics tested, but sometimes choose not to teach a topic because it is not relevant to their curriculum, or it does not appear on the statewide test their students must take. The same is true in most topical assessments of this type: teachers adhere to the curriculum content and do not often diverge. Lack of time is an issue, as is the testing system that does not include the topic. Unfortunately a systems approach for interdisciplinary science has not made sufficient advances to support teachers in a choice to add environmental material to the curriculum.

How much do people know about the science of the environment?

Research indicates teachers place a high priority on climate change as a topic their students should know, but report their own knowledge as inadequate for teaching it. Students (and some teachers) seem unable to distinguish among related environmental issues, and treat general "environmentally friendly" behavior as affecting all issues. The curricular fit of global climate change, for instance, is best in Earth systems oriented classrooms, but opportunities exist across the curriculum. Instructional materials are available, though these may not address misconceptions. Some interest groups oppose human–mediated climate change as a curriculum topic, for the same reasons they oppose public action on the problem.

Research indicates that there are some common misconceptions about environment and its issues. Many people, for instance, group all environmental issues into one mental cluster. They apparently see all issues as having the same causes, and therefore the same actions can reduce the problems. In very basic terms, environmental issues = "pollution", and the best thing to do about the issues is to recycle. We have clearly not tapped the potential for individual environmental actions, nor taught enough about the range of problems threatening the global environment.

In the case of climate change, for example, secondary school students (ages 11 and up) know that global climate change will be associated with changes in weather patterns, and they can basically describe how the greenhouse effect works to increase temperatures in the lower atmosphere. However, these students, as well as college students and preservice teachers, frequently hold incorrect perceptions about Earth system relationships as well as how human activities impact those systems. Results regarding misconceptions are remarkably similar across education levels. The most common misconceptions are:

- Inflated estimates of temperature change compared to IPCC estimates
- Confusion between CFCs, the ozone hole, and climate change (ozone layer depletion causes climate change; stop using aerosols to prevent global warming)
- Perceived evidence — warmer weather (reportedly they could personally sense rising climatic temperatures or changes in long–term weather)
- Confusing weather and climate

Teachers and global climate change were the subjects of other studies with different results to offer. A group of teachers in an inservice program about climate change appeared to feel strongly that their own behavior serves as a model for their students. Interview and journal data demonstrated they were conscious of showing best practice regarding their personal responsibility for global climate change. The teachers appeared to believe that if teachers show active interest and involvement in taking citizenship action, then students are more likely to do the same. This is a positive scenario that we hope is repeated in other teachers.

Is environment a key to sustainability and peace?

Sustainability has many meanings, but what it means to teachers may be most important here. A group of student teachers in Exeter, UK, provided some useful and insightful definitions. Each comes from a different student:

- "Sustainability involves an awareness of what is happening to the planet and an effort to protect and care for the Earth. It includes advances in technology and an understanding of the implications of these for the Earth".
- "Sustainability in terms of technological 'progress' is that which does not detract from, diminish or destroy what exists in the natural world".
- "Sustainability is the need for a balance between technological development for a better life for humans and the needs of the environment. It implies living within the Earth's carrying capacity and creating a global alliance".
- "Sustainability is the advance of technology in harmony with caring for the environment on a global scale".

Notice how frequently Technology is mentioned or implied within the definitions. These young teachers recognize that some environmental threats are linked to human actions as we develop our lifestyles. If this is true, there is probably a different view of environmental sustainability in developed countries and those that are struggling to develop technology. Some surprising revelations may be in store here. When the world was preparing for the Earth Summit in 1992, the Gallup organization did an international survey in 24 countries to determine how people felt about the health of the environment. In an open–ended question, a majority of people in 2/3 of the countries listed environment as one of the top three problems. Only economic issues were more prevalent in the lists. Even people in the poorer regions like Mexico, India and Chile ranked environment as a top issue.

Who is responsible for the problems? Across the 24 nations surveyed, respondents were most likely to blame business and industry as the major contributor to their own nation's problems. Next most likely causes were technology and wasteful practices, followed by lack of citizen education and poor government. Most people felt that the government had the primary responsibility for dealing with environmental problems, but they did acknowledge the importance of individuals and group actions as the second or third choice. In the lower-income nations, citizens are more likely to be seen as having major responsibility. This is an interesting finding, and it shows how closely survival in poor countries is tied to environmental quality. According to psychologists, most individuals prioritize their activities according to Maslow's hierarchy, taking care of personal survival needs (biological requirements, safety) first and holding the optional desires (esteem, involvement in causes) until primary needs are met. Environmental quality (protection of water supplies, for example) may be a determiner of biological survival where technology is not advanced, thus may be considered a primary need. There is also cause for caution in assessing technology's effects, as it is apparent that technology (defined by Gallup as "the way products are made uses too many resources and creates too much pollution"), while it may assist survival in some cases, is seen by many as a threat to the environment.

Peace is another issue. The optimists among us find great reason to see that cooperation for environmental quality could be a key to peace among nations. It only takes a satellite image of Mt. Pinatubo's volcanic ash plume, or a dusting of red African sand on our cars to remind us that environmental issues do not respect political boundaries. Those downwind of Chernobyl or the Iraqi oil fires, and those at the eastern end of the Mediterranean's cu-de-sac for beach debris, know that what is produced in one country may create problems for others. We all live downstream, and we all contribute to what goes into that stream. Likewise, when organisms in the flow of air or water are moving from place to place, their protection must come from all of us to guard the places where they come ashore to deposit their eggs , where they spend the other seasons, or where they stop over in migration. Care of sea turtles, migratory birds, whales, and monarch butterflies is a global responsibility. Nations that work together for the environment may just find that they can work together on other aspects of life as well! UNESCO, UNEP, the Global Environment Facility and other organizations are based on this premise. Is it important to school science and technology? If we value relevance in science teaching, and we are committed to development of literate citizens for a technological world, the answer must be "yes".

Research in the Greek and Turkish communities of Cyprus for Earth Day 1999 involved environmental professionals meeting on the topic of "Earth Learning, Earth Living". The attendees were asked to examine environmental issues on a list developed with the assistance of natural resource professionals in both communities. Some items on the list were issues only in one sector of the island, but the respondents rated all issues for their Significance, Certainty, Tangibility and Complexity. They also indicated how willing they were to act for the solution of the issues. A comparison of the Issue Significance responses and Willingness to Act, by community, is shown as Figure 2. While it is not possible from this research to determine whether Cypriots from all parts of the island would be willing to work *together* on environmental concerns, it is clear that the environmental professionals see the issues as very significant and are willing to take personal action on most. Events such as the "Earth learning, Earth living" conference help to make the politically separated peoples aware of their commonalities and their mutual dedication to environmental quality.

Peace using the environment as a context has important implications for students. All over the world, students have been joining each other in computer networks related to environmental monitoring, such as the GLOBE program (Global Learning and Observations to Benefit the Environment) which involves almost 200 countries. They know it is possible and desirable to communicate and share across cultures, and they are growing up with the expectation of being able to converse on an equal basis with their peers anywhere in the world. The journal *Technology & Learning* reported in January 2001 that the percentage of students accessing the internet from school is 78% in Sweden (the highest measured), 63% in Taiwan, 59% in the US and UK, 28% in Italy and Japan, 25% in France and Germany, and even 13% in urban sections of China. Students are literate in the technologies closest to them, and they expect this tool to put them in touch with people and information around the world. What they know of international warfare and intercultural conflict they learn from people who claim to be grown-ups. Just as the students become our mentors when we need computer assistance, they could teach us some things about relating to others around the world and sharing commitment to its environment.

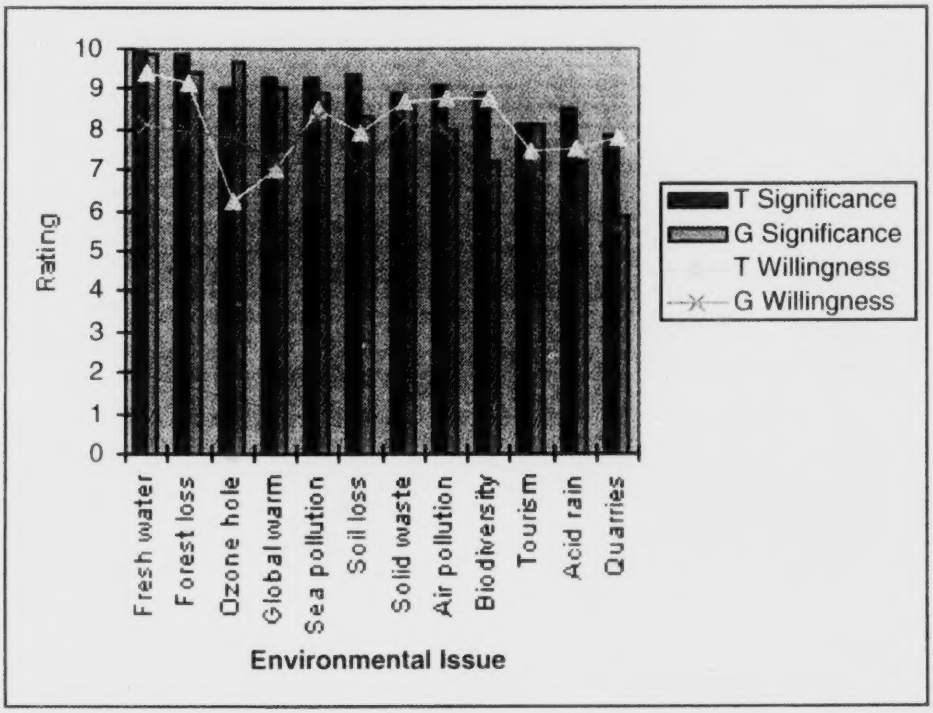


Fig. 2. Comparison of Significance ratings and Willingness to Act for selected Environmental Issues in Greek and Turkish Cypriot communities.

In autumn 2000 the Hellenic Marine Environment Protection Association (HELMEPA) published in its NEA newsletter a report of the children's Board of HELMEPA JUNIOR, a group aged 6–13 from nine regions of Greece that represents

3500 children nationally. The group drafted a resolution they hoped would be heard by the powerful on Earth. It included these lines:

> "Our everyday indifference, apathy and tolerance [of pollution] is nothing more than our complicity to the drama of the environment. Environmental Awareness is not enough but pressure from all of us to the grown–ups and to the Powerful on Earth is needed so that wishes and big words turn into ACTIONS".

How can we support the environment with what is learned in this conference?

"Where there is the will, there is a way!" In other words, if we are determined to do something, we will find a way to do it. Commitment to the principle of education that includes environment is the primary assumption, and the goal we wish to establish in our classrooms if the bridge to tomorrow is to be built. To use the wealth of information delivered here on science, technology and environment education, we must learn to think like a system. In a system, everything is connected to everything else, and education sometimes has difficulty relaying that concept to students. The tradition of educating teachers in discrete disciplines, the practice of changing classes, the separation of home from school, all create separate divisions in our thinking and enforce those divisions over space and time. Science ends for students when they leave our classroom. The teaching of biology is not intentionally integrated with the teaching of physics. School lessons don't have to be applied in real life. The problems are multitude.

If we approach learning about science, technology and the environment as a system, integrated among themselves and with the other subject areas in the school, we begin to find reasons to work together on lesson plans. We admit that we don't know everything about the environment (yet), or technology (ever), so we find colleagues who do know things, and we learn from each other. We share lesson plans, develop collective field trips and outdoor laboratories to make the learning relevant, examine new subject areas that cross over several sciences and perhaps add creative writing or role–playing about making decisions. Being part of a system frees the teacher to be creative and to continue building personal knowledge as well as teaching it to others.

There is a curriculum restructure effort in progress in many countries called *Earth Systems Education* (ESE). Designed for preschool through college, but focused mainly on secondary science classrooms, ESE makes Earth the focus of the curriculum. Students are taught how their surroundings here and now relate to the greater scales of time and space that characterize global topics. They work in cooperative groups to explore their environment using real data and precise observations, outdoors, on line, in labs and classrooms. In many cases environmental issues or natural systems are used as the subject matter for learning, because no part of the environment comprises just one discipline. ESE is taught through student investigations driven by interesting questions to be explored, so the sciences are learned on a need–to–know basis rather than as chapters in a given order in an encyclopedic textbook. It fosters appreciation of Earth's beauty and value, which rarely happens in traditional science classrooms. Even if we were studying the local rocks, their primary science of geology is subject to the changes brought by wind, sun and water. Rocks are broken down by plant and animal actions, and in turn support more growth and support for those organisms. Rocks are used in technology for buildings and carved monuments. Their strength and position determine their uses and dictate how they can support human-made structures and activities. They are woven into the legends that are our heritage. This is an example of how one common topic becomes the subject for Earth systems education.

Many of the questions investigated in Earth systems education relate to environmental issues and how human beings use the resources of the planet. Not only do such studies offer rich experiences with real data, and the need to consult many disciplines in search of answers, but they also provide a reason for doing science and a means of introducing the value of good stewardship of resources. Looking at the environment and how it is influenced by technology is integral to such studies.

ESE is guided by a framework of understandings that represent the goals of science teaching at all levels. These elements are also the basis of what many feel is important in global science literacy as well as much of what is traditionally considered the realm of environmental education. The scientific thinking and decision–making aspects of Earth systems education are appropriate bases for approaching environmental issues rationally.

Framework of Understandings for
Earth Systems Education

1. Earth is unique, a planet of rare beauty and great value.
2. Human activities, collective and individual, conscious and inadvertent, affect Earth systems.
3. The development of scientific thinking and technology increases our ability to understand and utilize Earth and space.
4. The Earth system is composed of the interacting subsystems of water, land, ice, air and life.
5. Earth is more than 4 billion years old, and its subsystems are continually evolving.
6. Earth is a small subsystem of a Solar system within the vast and ancient universe.
7. There are many people with careers and interests that involve study of Earth's origin, processes, and evolution.

The Sierra Club, one of the oldest environmental organizations in the world, has as its slogan, "Only one Earth". It implies that the choices individuals and nations make have a profound effect on the environment we all share, and that the opportunities to do things for and with the environment may only come once. If we deplete our nonrenewable energy resources or disrupt ecosystems with introduced species, we diminish what the Earth can offer for our future. Technology may be able to fix some of our mistakes and prolong the time before we will have to make hard decisions, but technology is a servant, not a saviour.

Part of every student's education should include the opportunity to see the world from a systems perspective, to take steps knowing that each decision alters the path ahead just a bit. We are all on the bridge, the environment that is taking us from where we are to where we will be. If that bridge is undergirded by educational foundations in research, if the things being learned are relevant, and the resources are diverse and modern, the path will be solid and supportive of forward progress in education. If the bridge has been strengthened by science taught as a system, by technology that enhances life and learning without detriment, the journey to tomorrow can be one toward global science literacy, with peace and sustainability.

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Sustainable Development and Environmental Balance as Goals in Science – Technology-Society Education

Abraham Blum, The Hebrew University of Jerusalem, Israel
blum@agri.huji.ac.il

The experience with general and integrated science

Most of our students will never become scientists or technologists, but they will have to live in a society that is becoming more and more influenced by new scientific discoveries and technological inventions. Gene technology, cloning, declining biodiversity, dangers from toxic residues, ozone depletion and the greenhouse effect are only a few of the topics which crucially influence the quality of our life. Though laymen, citizens will have to decide what quality of life they want, and what price they are ready to pay for it.

The idea to differentiate between science education of the few, who will become scientists or research technologists, and the majority of students, who need to be literate in the understanding of new scientific and technological developments and their actual and potential effects on the their life, is not new. Between the two world wars, *General Science* was taught in many countries as an alternative to the classical science disciplines. It was offered too often as an option for low ability students, and therefore it was not considered to be "respectable" by most science teachers and administrators. When the New Science curriculum movement started in the late 1950's and early 1960's, the leading projects were largely geared towards the future scientists. Some, like PSSC had the effect that the number of students who choose physics as science option even decreased. As counterbalance, more "humanistic" or technologically inclined science curricula were devised. Harvard Project Physics (Holton *et al.*, 1967) and the School Council's Project Technology, respectively, were typical cases. However, the *Integrated Science* curricula, which were developed towards the end of the 1960' and during the 1970's were more influential. They actually laid the ground for what we call today Science–Technology– Society (STS) teaching.

To show how relevant the thinking at the time was for our present approach, I would like to reiterate just a passage from the writing of one of the outstanding science education leaders of the time. Schwab wrote (already in 1964):

> "Industrial democracy has made science the foundation of national power and productivity. Science now plays the part once played by exploration, by empire and by colonial exploitation. It is this change in social role, which has changed the pattern of scientific inquiry".

Although many advocates endorsed the philosophy of a more meaningful *Integrated* Science education, the new subject did not succeed very well in its competition with the more prestigious "*pure*" science disciplines. Since the teaching of science and technology as "literacy for improvement of quality of life" builds on the integrated science teaching approach, it is important to understand why its predecessor found it so difficult to get a place under the sun. Although integrated science education brought more meaningfulness to the majority of students, it missed out on some crucial points:

1. Where scientists or university representatives had a major influence on science curriculum development and examinations (e.g. for university matriculation), they preferred "pure" science as basis for higher learning. Remembering *general* science, they thought that also integrated science had to be superficial.
2. Meaningful integrated science or STS teaching demands from teachers to go beyond the limits of the disciplines, in and for which they themselves were trained. This is a challenge to creative teachers, but to others the thought of it is already threatening. Staying in the realm of a discipline is "safer" for a science teacher than daring to deal with social, cultural and economic questions relating to science and technology, which students could bring up.
3. Some school system administrators misunderstood integrated science as meaning "combined" science and expected students to "cover" most of the "classic" disciplines, thus overburdening students with subject matter.

If we want to succeed in our scientific literacy education, we must think how to overcome these problems.

Sustainable development in science and technology education

Integrated science curricula emphasized societal issues, which dealt with science and technology. Unesco saw in this approach an important tool for development education, and therefore an advantage in the teaching of science in developing countries (Blum, 1971). At that time, the concept of *environmental* education was quite new. Thus, for instance, the first country to introduce environmental education legislation was the USA (Morrisett and Wiley, 1970), and many have not yet done so until now.

Many advocates of nature *conservation* blamed all development efforts for destroying the natural environment, not thinking too much about the need of many newly established countries to develop. On the other side, developers and national planners had not heard the term *sustainable development,* which was coined only twenty years later and used in an international document for the first time in the now famous Brundtland report of 1983.

When I was asked by Unesco to develop a rationale for integrated science teaching (Blum, 1973), I thought that "*environmental involvement*" should be a third dimension of integration, besides the *scope* of the integrated disciplines and the *intensity* of integration. Environmental involvement can be classified and taught at three levels (Blum, 1994):

1. *Description* of environmental issues, with the objective of bringing students to the level of (cognitive) understanding and (affective) responding;
2. *Search for a solution* to an environmental problem by applying the knowledge gained in a simulated situation, and working on alternative suggestions for a solution to the problem. This level demands higher intellectual skills and a higher degree of internalisation;
3. *Action taken* by students to actually improve the environmental quality in a realistic project. This level goes beyond the cognitive and affective domains into the world of hands–on action.

To become environmentally literate, at least the first level has to be reached, but students should get to the second level, and hopefully also to the third. This approach is a far way from traditional science teaching.

The Israeli approach to scientific and technological literacy

In the beginning of the 1990's, the Israeli Ministry of Education asked Prof. Hayim Harari, the President of Israel's prestigious Weizmann Institute of Science, and himself a well known physics researcher, to head a commission, which should review, re–think and re–plan science education towards the new century. Harari himself had been involved already in the past in science curriculum development. The commission came up with some revolutionary recommendations, which were taken up by the Ministry of Education. Among other points, the "Harari Report" of 1992 stressed the importance of literacy in basic "languages" like mathematics, the computer and science, besides the national language and English as international means of communication. The report recommended that all students in senior high school (10th to 12th school year), who did not opt for biology, chemistry, physics or technology, should study a new subject called "Science and Technology in Society",

The idea was to prepare science and technology literate citizens who could take part in the democratic decision making process about public issues, the understanding of which demands that kind of literacy. In Israel, the senior high school level is specially suited for this kind of life preparatory curriculum, because 96 percent of youngsters at that age level (16–18) are still attending school. They are in a developmental stage, in which they take a keen interest in public affairs, and are open to ideas how these could be handled in a better way.

The Harari Commission was aware of the problems, which prevented Integrated Science from taking off. With influential scientists as heads of the commission and of sub–committees, the recommendations had the backing of many scientists. Students with special inclinations towards science, "the future scientists and technologists", had still the option to choose a basic science or technology. The commission also made it clear that the STS approach means to choose a number of relevant topics and to prefer depth rather than "coverage". Therefore, no mandatory syllabus was devised. The "clever consumer" approach was applied, when curriculum development teams were invited to prepare modules (teaching–learning packages), from which teachers could choose according to the modules' "ingredients". Each of these modules should give the teacher enough materials for about 30–45 hours of instruction and offer alternative activities for students with different ability levels. Also, the modules should leave room for the teacher to add or delete learning activities. Thus, not all students would study the same topics, but all would be introduced into the integrated approach, which was described in the curriculum guidelines.

As a consequence, no nationwide examinations were expected, and instead of a final "paper and pencil" examination, a "portfolio" of students' achievements during the whole period of their studies would be compiled and serve as basis for the final evaluation.

The commission and the Ministry of Education knew that the new venture could succeed only after a serious in–service re–training of science and technology teachers, and with the help of qualified coaches. This is also the point where the whole scheme run into problems, when the education budget was redirected after a change in government. Now, with a new change in government and a unison demand from parliament to strengthen the educational system, the chances for enhanced teacher in–service training are again good.

The Yahas curriculum project

After the publication of the Harari Report, the Ministry of Education and the Israeli Science Teaching Centre contracted six curriculum development teams to prepare and test prototype modules. Among these was the Yahas project at the Hebrew University of Jerusalem, which I head. It specializes in sustainable development issues and environmental problems, which concern society. The Yahas approach is based on three questions, which relate to any environmental/development problem:

1. What factors created or aggravated the problem? (To answer the question, *scientific knowledge* has to be applied)
2. What *technological* solutions exist that can help to solve the problem?
3. What are the optimal solutions from the point of view of *society,* (whose members have often contradictory interests)?

So far, two modules were developed, tested and published. The first is called "***As air to breathing***" and treats air pollution. It starts with the dramatic case of the "pea soup thick" London smog of 1952, which ended with thousands of victims, but also triggered a major move towards the use of more environmentally friendly sources of fossil energy. This story brings up the inversion phenomenon, which can be easily demonstrated experimentally. The study of inversion leads to the movement of gases and the role of chimneys. Students use mini–Ringelman charts to estimate the content of solid particles in the smoke emitted from factory chimneys. They compare their results with data from other sources. But what about the "invisible enemies" – the gases? The student text uses charts and graphs to introduce the most common air pollutants in the country: sulfur oxides, which could be controlled through the use of better fuel, and nitrogen oxides which become more and more problematic, due to the growth of car traffic. Therefore, technologies like catalysers and electric cars are discussed as possible means to diminish air pollution. The visit to a power plant and a garage, which tests polluting emissions from cars, is suggested. Students learn also how power stations and electrostatic filters in chimneys function. They read news reports about the possibilities of using in future natural gas.

So far the emphasis in the module was on the scientific and technological aspects of air pollution. The next chapter is a case study of what happened when a power plant was planned close to the highest population concentration in the country. The different interests of central and local government, industry and city dwellers ended (typical for real life environmental situations) in a compromise. Students study the follow–up: What were the clashing interests? How far were the decisions taken positive, in hindsight? Where and how would you build a new power station (because nobody wants to live without electric energy)?

Another chapter is devoted to acid rain. Experiments with different concentrations of acid, which are applied to chalk and steel wool, simulate the effect of acid rain on buildings and sculptures. From the societal point of view, the main problem is that the acid rain comes from Europe and cannot be controlled locally. Students realise that international cooperation in the fight for a healthy environment is necessary. This leads to a discussion of other global problems like the greenhouse effect and the hole in the ozone layer. Students learn about different types of radiation, the electromagnetic spectrum and the special problem of UV radiation. They are confronted with clashing views on how serious the warming up effect might become, and learn how to accept uncertainty as a factor in decision making. Scientific information on the effect of CFCs leads to the search for alternative materials which are less damaging to the environment. Students study the qualities of these materials and check in supermarkets what sprays are being sold. They devise a local campaign to make the public more aware of the underlying environmental problem.

After students have studied alternative solutions to sustainable development problems, they are made aware that improvements cost money. The question arises: how much is the country (government, taxpayers etc) ready to pay for the neutralisation of pollution. With the help of a simple economic graph, , students learn to plot cost and benefit curves which show the cut-off point, where a relatively good solution can be reached for a relatively low price. "100 percent solutions" are usually unaffordable.

The package for teachers contains also task cards for two simulation games, which give students a chance for role playing. In one simulation, "representatives" from developing and industrialized nations, multinationals and greenpeace, each of which promotes a different interest, discuss how to plan energy consumption in a sustainable development approach. The classroom turns into an international forum, which decides what proposal to accept. In a second simulation game, advocates for different approaches to the improvement of city traffic and the reduction of air pollution, ask the class (acting as regional parliament) to vote which of the suggested solutions should be adopted.

"***Technology advances, but environmental quality is sustained***" is the title of the second module. As the name suggests, it is about sustainable development, translating the rationale of the Yahas project into learning activities. The module treats three technological issues, each of which is connected to an environmental problem. In order to find a balanced solution to each issue, it is necessary to understand concepts from different science disciplines. Many environmental problems, which we face in our modern world, were created by the use of technologies, which destroy the natural and social environment. To understand their mode of action, we must be "science literate" and be able to use popular scientific sources which can explain why a certain technology is unsafe or leads to unsustainable developments. Based on this literacy, we can then discuss alternative technologies and planning approaches, which (hopefully) are more sustainable.

The following table shows the three technological issues treated in the second module., the problems arising from the use of these technologies, the scientific topics which have to be understood to solve the respective problems, and the solutions which are suggested and discussed by students:

The technological issue	The problem	The scientific topic	The suggested solution
Expansion of a national airport	Noise as nuisance and damage	Acoustics, and the subjectivity of noise	Better planning, noise prevention technologies
Use of radioactive materials	Radiation hazards	Types of radiation	Safety measures
Pest management	Dangerous pesticides	Biological balance	Integrated pest management

In the sub-module "*Deafening noise*" much emphasis was placed on the subjectivity of noise. The central question is, if the present central airport could and should be enlarged, in spite of the noise pollution which affects the biggest population concentration in the country, or if an alternative airport should be planned – and if yes, where. This topic is since some years at the heart of a heated discussion, which will continue for quite some time.

Students rate if different sounds (including various types of music) are rather thrilling or a nuisance. Then, they ask their parents to do the same. The two ratings are not the same! In the next activity, students measure the decibel level at different places and again get different ratings. They learn that we often interprete subjectively what we hear, see and feel. A similar subjectivity is encountered when students are presented with expert statements, which are in the interest of one of the parties, while the others bring opposing statements, also from experts. The issue becomes even more problematic, when for instance the Airport Authority publishes a plan of the airport without showing the neighbouring towns, while the opponents emphasize how close the airport is to these towns and what decibel level was measured there.

The subjectivity of "noise" makes it difficult to devise laws to prevent it (or other nuisances that are below the real danger level, but are still diminishing the quality of life for the population in a given area). To enable citizens in a democracy to use their legal rights, e.g. to prevent changes in their environment which would create a serious nuisance, they have to know how to read by–laws. This demands another kind of literacy, which is seldom taught in school. Students also learn how to rank the issues involved in making decisions according to their importance and to give points to different alternatives, thus finding which of them has relatively more advantages over disadvantages, when the alternatives are compared.

The second sub-module is about the *use of radioactive materials in industry and health*. It starts with a survey of the sources of radiation in the vicinity in which students live. Then, students study basic concepts about radiation, generally, and radioactive radiation specifically. This leads to an exercise, in which students estimate the amount of radioactive radiation to which they were probably exposed during the last twelve months, from sources like cosmic radiation, the soil (radon), medical treatments like x–rays and closeness to nuclear installations. This shows them that the danger from radiation is small, assuming safety measures are strictly kept. Then they learn how different types of radiation are used in industry and medicine. They are asked to use this new knowledge to solve certain technological problems. Of course, the functioning of nuclear plants and nuclear submarines is explained, and the reasons for the Chernobyl disaster are discussed. After having learned about the positive and negative side of nuclear power plants, students play roles in a simulation game. Seven students argue as advocates of different interests for or against the construction of a nuclear power plant. The class, playing the role of parliament, discusses what action should be taken.

The third unit of the module, "*Chemical or biological pest control?*" begins with the citation from our holy scriptures, in which the damage by locusts to vegetation is described. Students learn about the relative advantages and disadvantages of chemical and biological pest control. DDT is introduced as a classical case for the shortsightedness in the use of synthetic chemicals. The developer of DDT, Muller, received the Nobel price mainly due to the two qualities of DDT, which made it necessary to ban it all over the world. These qualities were: the wide range of harmful insects it could kill, and its longevity, which meant that it had a long lasting effect. Today we know that these two qualities are very bad. DDT kills also the beneficial insects, and its long lasting action before disintegration has brought about very serious unbalances in nature.

Students study biological control in the classroom by growing on Petri dishes fungi, which can cause plant diseases, and opposite them fungicidal bacteria. The results are dramatic. Then integrated pest control is introduced as the optimal solution. This is done mainly through a video film, which shows the action of the revolutionary "solarisation" method developed at our university. In this methodology, which is suitable for regions with hot and dry months, solar heat is caught under plastic, which covers the soil. The heat kills many disease-causing microorganisms without harming the useful ones. The video was based on an instructional film produced by the extension department of the Ministry of Agriculture. We cut out technical details, which are not important for high school students, and divided the film into five sections, each of which ends with a question for students to answer. Teachers are advised to show the film section by section, and then again as a whole, to create closure.

The solarisation method uses safe solar heating instead of the ozone destroying methyl bromide, which was used so far for soil sterilisation. Is this the happy end of the story? What about the polyethylene sheets which remain in the field without discomposing and thus harm the coming crops? Sure enough, plastic sheets, which discompose after being exposed to a certain amount of sunshine, were developed, but so far their price is too high for farmers. Again, the economic problem prevents (so far) a clever invention from being used to sustain development.

Let me finish with the most important experience from implementing the Yahas curriculum. It lets teachers and students realise that technology and environment, development and sustainability are not necessarily incompatible. As the name of the module argues: technology can advance, and quality of the environment can still be sustained or even improved.

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Science and Environmental Education: Can They Really be Integrated?

Vasiliki Papadimitriou, University of Thessaly
vaspapad@uth.gr

ABSTRACT

Environmental Education since its emergence, through the international conferences of the 70s, has been described as an interdisciplinary field which means that it requires contributions from a number of other disciplines, science being one of them. Many educators have questioned the possibility of traditional school disciplines to promote the Belgrade Charter view of environmental education, because of the content taught, the authoritarian teacher– student relationships, the methodologies followed in teaching, the avoidance of handling controversy in the classroom, etc. In this paper it is suggested that taking into account the poor delivery of environmental education, after about thirty years of its existence, in educational systems, it would be more productive to try to find the aspects that unify science and environmental education.

In this paper firstly, there are briefly examined the current status of environmental education in school curricula and the current views about science education. The organization, the content, and the processes followed in teaching, of a science course for prospective primary school teachers are described. This course is inspired by the ideas expressed in the STS movement, and its main characteristic is that, contexts for teaching science had been issues from every day life such as the environmental ones. Some evaluation results are presented supporting the thesis that merging science and environmental education is mutually beneficial.

INTRODUCTION

Environmental education since its emergence, through the international conferences of the 70s, has been characterized as an interdisciplinary field which means that it requires contributions from a number of other disciplines. Concerning its delivery in formal education, a common thesis was that it cannot be a separate self–contained subject but rather that it should be integrated to all disciplines taught in school. There was a widespread view that science would be one of the main subjects of the school curriculum that can accommodate environmental education. But in an early stage there were educators who questioned the possibilities of school disciplines, science included, to promote the Belgrade Charter view of environmental education (for instance: Lucas, 1980; Robottom, 1983; Robottom, 1984; Maher, 1986). They argued that the structure of school disciplines, the authoritarian teacher– student relationships, the text base patterns of instruction, the avoidance of handling controversy in the classroom, can only promote the less controversial components of environmental education as it is knowledge and skill development. Which means that it promotes the education *in* and *about the environment* while neglecting the education *for the* environment, which is more radical, as it is focused mainly on the ethical dimensions of the issues, the promotion of critical thinking, attitudes and behavior. In advance for school science, Robottom (1983) argues that this subject is a limited vehicle and for the reason that it promotes a positivistic world–view not compatible with the aims of environmental education.

This paper, argues that a careful look at many of the proposals concerning the aims, the content and the teaching methods for both environmental and science education as far as the new trends of the later is concerned, many things exist in common. From this comparison one can arrive at the conclusion that science education does have a central role to play in promoting environmental education from which a reciprocal benefit can be derived.

So in this paper firstly, are briefly examined the current status of environmental education in school curricula, the current views about science education, and its relation to environmental education is outlined. Then a science course organized for student–teachers is briefly described and some evaluation results are presented supporting the thesis of this paper that merging science and environmental education is mutually beneficial.

ENVIRONMENTAL EDUCATION IN SCHOOL CURRICULA

In spite of the enthusiasm that accompanied the emergence of environmental education in terms of its promotion, it remains a fact beyond dispute that its incorporation into the educational systems all over the world is still problematic. A lot of progress has been done by producing teaching materials, of high standards in many cases, many successful practices have been reported, a lot of research evidence is available but in practice environmental education has not been part of all pupils' education. No country can claim that has fully incorporated environmental education into the school curricula, in spite of the many official statements. I will refer to the specific case of two countries. One will be U.K. where environmental education is officially considered as a cross curricular area and my country, Greece, where environmental education is implemented through separate projects dealing with environmental issues.

In England, according to Oulton (1994), "Curriculum Guidance 7, using the well rehearsed formula of education *about, in* and *for* the environment, sets out the way in which this may be achieved through the contribution of individual subjects and by the development of a co–ordinated policy across both the formal and non-formal aspects…". But as he points out, the documentation in not statutory such as in English and science which means that the guidance to schools is about what *should* do rather than what they *must* do. In practice, the disciplines that mainly accommodate environmental education within the timetable curriculum are science and geography (Gayford, 1996). According to Oulton's (1994) views "...although there are some teachers that are carrying effective environmental education strategies in many schools and a few schools are beginning to consider whole school strategies, the vast majority of pupils do not currently receive a comprehensive environmental education experience".

In Greece, environmental education has the official recognition, but the form which is supported by the Ministry of Education is the implementation of separate projects. This has as a consequence environmental education to remain in the periphery of the curriculum. This is one of the reasons that only some motivated teachers are involved, doing in many cases of high quality work, but usually after implementing one or two projects, they give up the effort because they face many difficulties. They have to invest extra time as very often they work outside of the school timetable during the implementation of the project. It is estimated that only 10% of the teachers are involved each year, which means that environmental education is optional for pupils.

Taking into account the poor delivery of environmental education in formal education, for a variety of reasons, the role of school in promoting the environmental literacy of all citizens is at least questionable.

NEW TRENDS IN SCIENCE EDUCATION

If we take a fresh look at the relation between science and environmental education we will have to seriously consider the changing views overtime concerning science education. For the last decades there has been a tendency to renew science education at schools so as to respond to the new transformations that occur in society. School science, had been criticized by many educators and others for being taught as though all pupils should become practicing scientists. In advance, research on pupils' alternative conceptions unfolded problems related to teaching and learning and a view has been established that science knowledge taught in school is not internalized (for instance: Driver et al, 1985; Osborne et. al, 1987).

There have been calls for transforming science education from something focused on abstract factual knowledge promoting fragmented learning to a discipline focused on preparing future citizens able to understand and cope with the science related societal issues. Scientific literacy for all citizens, becomes the new focus of science education. Hurd (1998), one of the supporters of these changes, mentions that science itself is changing in many terms. He points out that science is becoming more holistic in nature and in practice, there is a move from single disciplinary based studies to cross–disciplinary ones. Research is now focused mainly on the functional aspects of science/technology as it relates to human welfare, economic development, social progress, and the quality of life than in the establishment of new theories and laws as happened in the past.

As a response action to these views the movement STS (Science, Technology & Society) came into being. STS education has as its focus the scientific literacy of all students independently of the profession they are going to follow. It aims to equip learners with the knowledge and skills needed to cope with and successfully resolve personal and societal problems (see for instance Bybee, 1984; Hofstein & Yager 1982; Miller, 1984; Yager, 1992; Solomon & Aikenhead, 1994).

In the last decade, the terms "public understanding of science" and "social responsibility of science" are connected to science education at schools. The first one, according to Cross (1999), is used by those who see it as a means of furthering the continued development of the technocratic society and aims to educate people to support and cope with what the experts provide rather than to question their products. The second is characterized as more radical and is used by those who connect the overcoming of the environmental and ecological threats facing the world, with some kind of social change.

Focusing science education on preparing scientifically literate citizens prerequisites many changes concerning the content, the organization and the pedagogy of school science. According to Yager et al (1995), "there is the perceived need for something different from the conceptual schemes (discipline structures) used by practicing scientists. Different organizers are needed in schools. … and the new organizers should be issue based…". Some characteristics of the STS approach are the deep involvement of students in investigating problems and the promotion of a multidisciplinary view, as problems have not only scientific aspects.

It seems that science education once again in its history is on its way to transformation so as to respond to the demands of the present digital era where science as a discipline play a vital role in many ways in our every day life. But changing the well–established tradition in science education is not an easy task. This is the reason why STS movement although it has gained an extended support, as one can judge from the literature, its translation to school practice still remains problematic. A number of different approaches are being explored, and at the same time, many questions arise concerning the content, the outcomes of the STS curricula, and the way of integrating these into current science education practice. McFadden (1991), based on the experience of a Canadian STS curriculum, discusses some of the problems that arise in practice.

Comparing the proposals concerning the current views about science education just outlined and the views held about environmental education one can notice that these fields have many in common as far as the aims, the content and the teaching methods are concerned. Volk (1984) points out many of the common goals and practices that these fields share. For science education dealing with environmental issues, add relevance to learning, as these are real problems, and so will be seen by students as worthy of consideration. On the basis that maintaining the health of the environment is going to be the most important task that the humanity will face in the future, education must play a vital role for that. Environmental literacy apart from environmental concern, prerequisites some knowledge from many areas, science included. The development of problem solving and decision making skills is common aim for both science and environmental education. Zoller (1987), one of the supporters of the teaching of science through the environmental issues (STES education) emphasizes the possibilities for enhancing problem solving and decision making skills. Science education in its way to transformation may very well find an ally and resource in environmental education concerning practice. Many teaching approaches such as active involvement of students, issue investigation, analysis, evaluation of alternative solutions to problems etc. have developed, in the field of environmental education and some teachers have been familiarized with them, science teachers included.

INTEGRATING SCIENCE AND ENVIRONMENTAL EDUCATION INTO INITIAL TEACHER EDUCATION

In Greece the majority of the students come to Primary Education Departments from high school with a very poor background in science, as science is not one of the subjects taught as sine qua non for university entrance examinations. Also research evidence has confirmed their poor understanding of many basic science concepts (Papadimitriou, et al., 1993; Papadimitriou, 1994). It thus appears that science taught in schools does not help them understand the scientific part of every day life issues.

On the basis of the belief that merging environmental education and science education, would be mutually beneficial, we attempted to organize a science course for prospective primary school teachers. The main feature of that course is that science concepts are taught not in the context of the discipline but in the context of issues from every day life, such as the environmental ones.

It has been assumed that this way would be more attractive for students and more effective in providing them with the necessary science knowledge for both their own scientific and environmental literacy and their professional development. Inherent is the hope that if teachers get familiar with innovative ways of teaching and learning during their initial teacher training, they will adapt more easily such ways in their practice when they become teachers.

Content and process of the course

The environmental issues selected to constitute the context for teaching, were the following: drinking water, greenhouse effect, ozone layer depletion, acid rain and plastics. These were selected on the basis of their importance in our every day life and because these can impart a great deal of science knowledge. For each one of these issues modules were prepared in which, apart from the scientific part, emphasis is given to other dimensions of these issues as well, through stimulus materials and background information in the form of printed information which provided as part of each module.

46 students, in their first year of studies, participated in the course, which lasted one semester for 3 hours per week. Students worked in groups of four, implemented the proper experiments in each section, observed the results and responded to them. They

were prompted to discuss their findings with other students in the group and with tutors. Emphasis was placed on the use of scientific knowledge in terms of the issue. By using the supporting materials, that accompany each module, and with the help of stimulus questions, students were encouraged to discuss, analyze and reflect on several dimensions of issues such as scientific, social, political and economic and also to seek solutions to the problems.

Evaluation and outcomes

The evaluation of the course was based on pre– and post– instruction questionnaires. Not all the expected outcomes were evaluated during this stage of the course. In fact, at this stage the evaluation focused mainly on the cognitive outcomes in relation to the particular issues, which were focused on finding out students' understanding of each one of these issues, as well as their ability to use scientific terms in expressing their views. So each one of the questions were of an open type aiming at finding:

(a) What they know about each one particular issue

(b) Their views about the compounds that cause it

(c) Where these compounds come from

(d) Their views about consequences of the environmental problem

In both questionnaires students were asked the same questions. The post–instruction questionnaire was given to them one week after finishing the course.

The findings from this evaluation have been presented and discussed in detail elsewhere (Papadimitriou, 1995, 2000a, 2000b). Here, only some extracts of these data will be presented for supporting the claims of this paper concerning the benefits gained of this kind of course for both science and environmental education.

Benefits for science education

In the following table some data, coming from the pre– and post– instruction questionnaires, which concern the learning in science and the application of the knowledge learned in understanding scientific aspects of three environmental problems –acid rain, greenhouse effect and ozone layer depletion– are presented.

Students' responses to the questions concerning the scientific aspects of the three phenomena.

The main categories of students' responses	Pre- instr. n=46	Post-instr. n=46
ACID RAIN		
Rain that contains acids or acidic compounds	7	39
Mention the H_2SO_4 or HNO3 or both	-	44
Rain that contains pollutants	25	3
Rain with pH <5,6	-	31
Responsible compounds for acid rain are sulfur and nitrogen oxides	9	39
GREENHOUSE EFFECT		
Temperature rise because of the absorption of solar radiation	23	45
Mention UV radiation	6	42
Mention only (CO2) as greenhouse gas	16	7
Mention more than one of the greenhouse gases	3	36
OZONE LAYER DEPLETION		
The ozone exists in the upper atmosphere	6	42
Mention the ozone of the lower atmosphere	-	29
Destruction of the ozone caused by the content of the sprays (without mentioning the CFCs)	25	5
Destruction of the ozone caused by CFCs	3	41

The number of answers exceeded the number of students (46) as some of them gave more than one answer.

Some of the conclusions drawn form the evaluation can be summarized as follows:

Remarkable progress in using more scientific terms in students' language can be noticed by looking at their answers in the above table. For instance the number of students who give the scientifically acceptable views has considerably increased after instruction, as 39 of them mention sulfur oxides and nitrogen oxides as the compounds that cause acid rain, while in the pre–instruction questionnaire only in 9 of their answers refer to oxides.

Apart from the data summarized in the table there are some other findings deserving attention. Part of them concern students' views about the consequences of the acid rain. In their pre–instruction answers to this question the majority uses more generalized terms as «harmful rain», «has caustic effects», «catastrophic», «makes holes», «blackens the buildings as, for instance, in Athens», «harmful for people because it contains dangerous acids». While in the post instruction questionnaire their answers are more specific as they mention that acid rain is harmful for vegetation, for organisms in the aquatic environments, for ground, for buildings and monuments.

Another point worth mentioning is the improvement of their performance in writing chemical formulas and chemical equations. So in the pre– instruction questionnaire, only few (5 out of 46) wrote 1–3 chemical formulas overall and no one wrote even one chemical equation. While in their responses to post–instruction questionnaire although they were not asked to do so, the majority wrote many of them. More specifically, 27 wrote the chemical formulas of the oxides, 29 of the sulfuric acid, 13 of the nitric acid. Also a considerable number of them wrote the chemical equations of the reaction of the $SO3$ with water and the reaction of sulfuric acid with the $CaCO3$ when they mention the harm that acid rain causes to marbles.

Benefits for environmental education

The discussion concerning the benefits for environmental education will be focused on describing briefly of what came out in dealing with one of the issues, the drinking water, as students showed a special interest for this because it is a local problem of great concern. What they knew from the beginning was that there is a problem with drinking water in the city where they live because of the peculiar taste it has.

With the help of the scientific knowledge they gained, the relevant supporting material, and the stimulus questions they discussed about different aspects of the issue such as: the factors that affect the quality of water, the problems connected to the availability, the policies on the part of the government and local authorities, the local conflicts around the water, the role of the industry, the actions of the farmers, the role of the citizens, the ethics implied. They also stimulated, through the questions, to discuss possible solutions to the problem. In their discussion they made use many times of the science knowledge gained such in the discussion concerning the quality of the bottled water by examining the analysis written on labels, also in discussing the purification process before the water reaches our home. Some who live outside the city in close villages asked for permission to borrow the chemicals used in the lab to test for nitrates in the water they drink. They discussed about the climate change and the ground water availability, also examined the international dimension of the problem in connection with conflicts in Middle East and with development by comparing, through given charts, the consumption of water in different areas of the planet.

In conclusion, during the study about each one of the environmental issues they had the opportunity to meet many of the aims of environmental education, such as awareness, holistic approach, handling controversy, opportunities for developing communication and critical thinking skills, examination of alternative solutions to the problems.

CONCLUSIONS AND IMPLICATIONS

In the begging this paper briefly discussed the problems and the constraints in delivering environmental education in schools. If environmental education is to be seriously considered, by the educational community, as a dimension of the traditional disciplines, (science included) the emphasis must not only laid on its contribution in raising awareness about the environment and in the formation of developing attitudes, but also on its potential to contribute to the achievement of the particular goals of each one of these disciplines and of the education as a whole.

The evaluation of the course just described showed that the approach and strategy adopted, constitute in themselves a way of integrating science and environmental education, rendering them mutually beneficial. It appears that students gain a better understanding of science concepts, a better understanding of the issues studied, and the ability to use science knowledge that have learned, in dealing with different aspects of these issues. Also the content and the process followed construct a framework meeting many of the goals of environmental education.

The course described it is not seen as an end in itself; it needs improvements in both, the content and the process followed. For instance we think of involving some fieldwork. It is important to train prospective teachers through such innovative courses so as to become familiar with approaches that meet both the aims of science and environmental education as well. Such familiarization entails the possibility of adapting such approaches in their school practice.

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Community-Based Science-Technology-Society Education – A Case Study

Revital T. Tal, Israel Institute of Technology, Israel
rtal@tx.technion.ac.il

The paper presents a case study of school-community collaboration in an elementary community school (grades1–6) in Israel. The development of environmental education school-based curriculum was at the core of this effort. The collaboration was established in the framework of the *Community School Approach*, which is practiced in many schools in Israel. In these schools parents are encouraged to be involved in planning school-based curriculum. The idea of community of learners (Beriter & Scardamelia, 1993; Crawford, Krajcik & Marx, 1999; Gallagher, 1989) is examined here under the perception of the school's community as a large learning community.

The aim of the study was to describe school-community partnership and examine the advantages and limitations for community-based collaboration, emphasizing local ideas of project-based learning in environmental education (EE).

The study describes an exemplary collaboration and the development of local school-community partnership, which can be adopted and adapted by other communities within elementary or middle schools.

THEORETICAL BACKGROUND

Schools should be considered legitimate in the eyes of their relevant publics. The basic community approach perceives schools as communities rather than organizations (Sergiovanni, 1994). Families, friendship networks and social clubs are examples of organized collections of people that are different from formal organizations that have defined structures. Sergiovanni based his ideas on the distinction between *gesellschaft* (society) and *gemeinschaft* (community) made by the German sociologist Tonnies in 1887. The community school approach, which relates to the relationships between families, social clubs, volunteers and individuals who share emotions and values, is based on the second (Tonnies, 1887 in Sergiovanni, 1994).

Social interaction among learners is a basic principle of social constructivism (Driver, Asoko, Leach, Mortimer & Scott, 1994; Guaskel, 1994). Dewey (1938) was the first one to emphasize learning science in a community environment, which allows the student to challenge real life problems. Vygotsky (1978) had argued that knowledge is a socially constructed entity, which is developed as a result of continuous negotiation and collaboration among individuals as part of society. Different abilities of students allow addressing out possible differences with various types of social interactions within the school. Goodlad (1984) has recommended the involvement of the broader community in school life in order to encourage substantial educational reform. He suggested that schools encourage volunteers from all areas of life to engage in school activities. The importance of community involvement in a meaningful school reform has been emphasized in the last two decades (Fullan, 1997). A school's community, which includes parents, social institutions and municipalities, should be part of that effort. Criticism towards traditional schools often refers to the artificial learning environment, emphasizing mainly formal knowledge and skills, while neglecting other domains such as collaboration in building of community knowledge (Bereiter & Scardamalia, 1993).

In addressing the issue of community building in schools, Sergiovanni (1994) argues that "community is the tie that binds students and teachers together in special ways, to something more significant than themselves: shared values and ideals" (p.xiii). A school's community usually refers to students, teachers and faculty within the school, but also includes parents and community members. Sharan, Shachar and Levine (1999) suggest that parents' involvement in school should be above and beyond the common planning of social activities or even maintaining close relationships between teachers and parents. Schools should establish productive relationships with many different settings in the community. Municipalities, institutions and local organizations must assist in creating the legal and procedural framework needed to make students study out of the school-building a matter of routine.

Aspects of community involvement as part of the Science-Technology-Society movement include rephrasing the goals of science education (Bybee, 1993) and interaction with different stakeholders (Staley, 1993) as part of learning in "real life" environments. Gray (1984) listed nine major steps for creating school-community partnerships, including identifying needs, creating programs and implementing and evaluating them. Family involvement in school activities was found to be positive in both cognitive and affective domains (Dierking & Falk, 1994). Environmental education in particular is emphasized as being elevated by school-community partnership (Ben-Peretz, 1980; Evans et al., 1996; Gallagher et al., 2000; Wheeler et al., 1996). Learning science and technology in collaborative environments requires various levels of collaboration within the classrooms, as well with people and groups outside the classrooms (Blumenfeld et al., 1996; Crawford, Krajcik & Marx, 1999). Inquiry is one of the best paths towards creating communities of learners.

GOALS

The purposes of the study were to describe and analyze a school-community collaboration, which focuses on curricular activities, and to identify and discuss the advantages and limitations of this collaboration.

METHOD

Setting

The school described here is an elementary school (grades 1–6) with a population of about 450 students in the north of Israel. The school serves a middle and upper-middle class community. Many of the people who moved into this community expressed their interest in influencing their children education. The schools' mission, which was developed by teachers and parents, declares that school should serve the community at large, and that its programs should reflect community issues. The school's curriculum incorporates both national mandatory subjects and local programs designed by the community. The school's resources are based on the personal and professional potential of the teachers, community institutions and the whole target population. The school represents a large stream of schools, seeks for intensive community involvement and fits the basic nature of the *Community School Approach*.

Participants

The participants in this study were parents, teachers, students and other community members who took part in various collaborative events. Interviews with twenty-five community members were conducted in two sessions. The interviewees participated in the major collaborative events and represented different age-groups and class/school activities.

Data sources and analysis

The sources of data originated from three years of participant observations in various school-community activities, and from open and semi-structured interviews with the school faculty, parents and community members, which took place during the third year. Figure 1 presents the three stages of data collection and the end product of each stage.

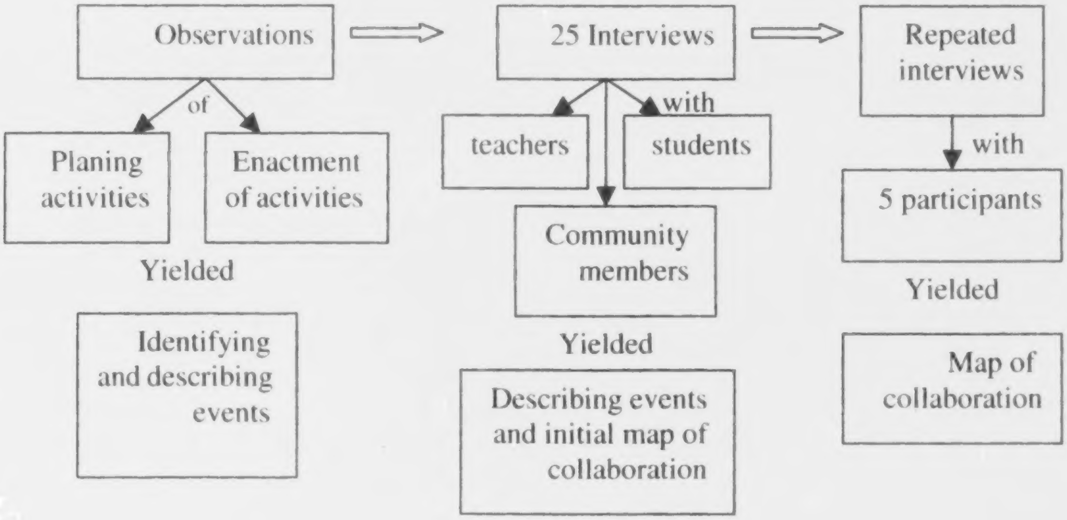
Observations
of
Planing activities
Enactment of activities
Yielded
Identifying and describing events
25 Interviews
with
teachers
students
Community members
Yielded
Describing events and initial map of collaboration
Repeated interviews
with
5 participants
Yielded
Map of collaboration

Figure 1. Structure of data collection and analysis

The observations provided the necessary knowledge about the key events and about target people for the interviews. Observing the same activities over three years permitted us to follow changes and development and to focus on these processes during the interviews. Overall, there were twenty-five interviews with teachers (5), parents (12), sixth-grade students (5) and community members (3). Each interview lasted about 30-60 minutes. Illustrative key questions were:

- Do you think that collaboration within the school community exists?
- Can you describe such collaboration/relationships?
- In what ways do you think this collaboration contributes to learning?
- Who is responsible for maintaining this collaboration?
- Do you think that parents/students/community members have the right to be involved in curricular decisions?
- Would you like to be involved in curriculum planning? Why?
- What are the limitations of this collaboration?
- Were you personally involved in school-community activities? Can you describe your role and your experience?

The main events were identified through the observations. A list of approximately ten events, which involved parents and/or community involvement, was created. The long-term observations and the first set of interviews were used for describing the events. The interviewees were asked to draw a map, which explains the relationships they found within the school and its community. The participants were asked to use only their own experience and to relate only to events in which they participated during that year. The maps were collected and analyzed relying on the observation data. Five maps were then presented at the second set of the interviews. The repeated interviews, with five representatives of different sub-groups (two teachers, two parents and one student) were used for drawing a final "map of collaboration" (see figure 3). They were asked to critique the scheme, add possible links or erase others. Findings from these repeated interviews intended to confirm, refine or reject the categories raised at the observation stage and from the first set of interviews.

FINDINGS

In this section we present a short summary of the first interview set, which focused on issues of initiatives, participation and responsibility. Then we summarize the main efforts, and finally – summarize the second set of interviews, which allowed us to draw a relationship map.

General analysis of the interviews shows that all the participants think collaboration exists. They were all able to describe at least one substantial example. There was less agreement on the issue of responsibility. Most of the teachers think it is the school's responsibility to maintain and control collaboration efforts, while some of the parents agree with the teachers and others think that it is the parents' responsibility.

All the participants thought they should be involved in curricular decisions or "macro-planing" a term that was suggested by one of the parents. Example for planning are: school projects, enrichment activities and courses. Only a minority of all the interviewees thought parents should be involved in everyday curriculum planning. Most of them acknowledged "teacher professionalism" as the main reason and many stated that although involvement in general is positive, parents have their own agenda and they cannot be committed on a regular basis. Some of the students said that they would not like their parents to become like teachers.

Detailed analysis of the observation data and the first set of interviews raised six main examples for community-school collaboration, which are presented in Table 1.

Table 1. Collaborative efforts and type of involvement

Collaborative efforts	*Type of involvement*	*No. of events*	*Duration of*
Field trips	Planning, participating, guiding	40	Usually 1 day each
Class projects	Planning, mentoring, participating	4	1–4 weeks
Annual Independence Day	Planning, participating, guiding	1	1 week
Industry-Environment project	Planning, participating, mentoring	1	8 weeks
Environmental contribution	Planning, participating	2	1 day
Teachers' professional development	Planning, mentoring	5	1day

The collaborative efforts

1. Field trips. The school's program sustains about forty-five field trips per academic year: six to ten trips per class, which relate to the science, environmental education and social studies interdisciplinary school curriculum.

Managing this complex system demands a major effort. Therefore, the school staff called for establishing a community *Environmental Education Committee*, which consists of three science and environmental education teachers and three parents who have a rich professional experience with educative field trips. The committee met three to four times a year to plan the field trips, choose nature trails, and suggest field activities. On a few occasions, the parents took an active part in conducting and guiding the actual field trips with other parents, school faculty and the students. After each field trip there is a feedback discussion with the students, both teachers and students write their reflection, which are discussed at the committee meeting for future modifications.

2. Annual Independence Day activity. This activity is a whole school activity, which takes place once a year around the Independence Day of Israel. Combining the community involvement in environmental education and the intensive program of field trips had influenced teachers and parents to enact a special learning opportunity – a whole day of re-enactment of an historical event. A different historical event is chosen every year. Each event is rooted in the struggle for independence. Teachers and community members plan a set of learning activities for different class levels. Volunteer parents and teachers survey the hiking trails, learn the environment and develop suitable field activities for every class level. Each class, accompanied by parents re-enacts its part of the historic event. Then everyone joins together for a memorial ceremony. Parents and community officials are invited to take part in the activity.

3. Yearly Classroom Projects. Most of the classrooms conduct yearly projects focused on key themes, usually a part of the science curriculum. Parents are generally invited to collaborate with the school faculty in the projects. The parents' role is different in each project and so is the number of parents who are involved. In some projects, each parent supports his/her own child, while in others, volunteer parents guide teams of students. In both examples parents receive basic instruction by the teachers and collaborate with them during the various stages of the projects. Table 2 presents examples of themes for yearly projects with activities and the main concepts learned.

Table 2. Yearly class-level projects

Table 2. *Yearly class-level projects*

Grade	Theme	Activities	Concepts
2	The scientific collection	Students collect and exhibit natural scientific collections of flowers, leaves, rocks, soil, feathers etc.	Taxonomy, sorting, labeling, scientific method, presentation.
4	The olive tree	Team-inquiry focused on scientific, historical and cultural aspects of olives and the olive tree. Groups present their projects either by posters, plays or computerized presentations.	Olive orchard, oil, fat, light, nourishment, cultural/ethnic symbols.
5	Bird research	Students choose a research topic for 2 months. Birds are in the center, but the focus can be on science (ornithology), literature or culture. End of project is an exhibition, where students and families share knowledge.	Scientific research: research question, methodology, collecting data, using references, writing a report, presentation.
6	* Industry-Environment	Experiencing the manufacturing process, marketing, making environmental considerations visiting plants, writing team portfolio.	Handcraft vs. industry machines, modern design, pollution, and sustainable development.

* Is discussed in details in the next section

4. Industry-Environment Project. The Industry-Environment Project is the inclusive summary of the school-based environmental education curriculum. The project was discussed in details in previous papers (Dori & Tal, 2000; Tal, Dori & Lazarowitz, 1996; Tal, Dori & Lazarowitz, 2000). This is an eight week after school project where groups of 10 students and 2 parents are working together doing inquiry, designing and building prototypes and models of products that influence our quality of life, while applying environmental considerations.

The sixth grade science and environment school-based curriculum incorporates ancient and modern agriculture, geographical formations, industrial and environmental issues. At the center of the curriculum are an eight-week project, case studies and field trips that involve industrial, natural, environmental and societal aspects of industrial development. The community project is carried out informally after school hours.

Parents, students and teachers choose a new industry and environment related theme each year. Then student teams, guided by volunteer parents and experts, study the scientific background related to the project theme. Most of the team meetings are held during evening hours. The teachers function as participant observers and advise the mentors. Various experts from the community give guest lectures at the group meetings or to the whole student population. The final products and group portfolios are presented to the public and go through a process of community assessment.

5. Science and technology professional development. Community involvement in teachers' professional development occurs in two different ways: (1) financing informal professional activities of the teachers, and (2) providing volunteers who support science and technology education by meeting with the teachers during evening hours and helping each group of teachers according to its special needs (content knowledge, technology, etc.). "The technology experts" is a group of five community members who give continuing support to the teachers in using and implementing information technology in the classrooms. The "experts" also serve on a community committee for purchasing and upgrading the school's hardware and software.

Collaboration map

Figure 2 presents the Collaboration Map, which emerged after the first set of interviews, and was then critiqued and refined during the second set.

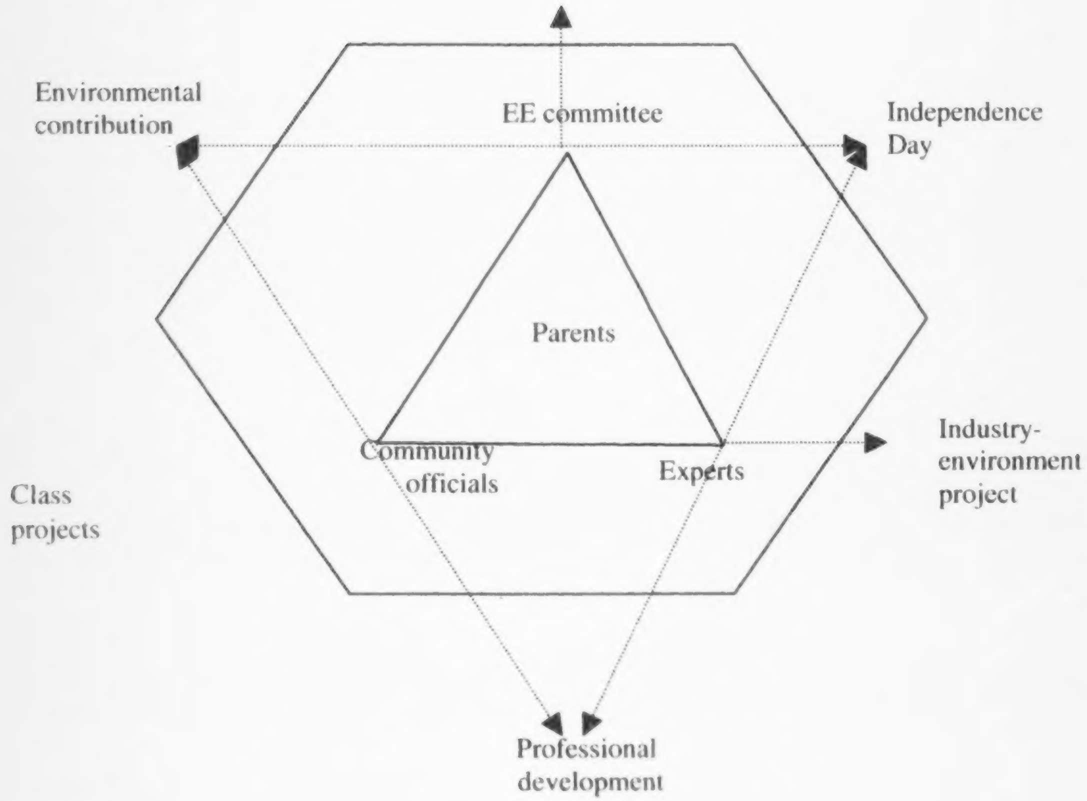
Environmental contribution
EE committee
Independence Day
Parents
Industry-environment project
Community officials
Experts
Class projects
Professional development

Figure 2. Collaboration map

The central triangle represents the community agents (parents, EE committee, experts and community officials) who are involved in the school. The parents who are presented in the middle are connected to all other agents and events. They are involved on all levels in the activities. The outer hexagon represents the major events. The Environmental Education committee (agent) is influential and involved in field trips, Independence Day activities and with environmental contribution activities (events). Community experts in various domains (agent) are involved with Independence Day activities, Industry-Environment Project and with professional development in the school. Community officials (i.e municipality representatives) support "environmental contribution" activities and professional development. Parents alone usually support classroom projects.

Because the community is rather small, sometimes the interviewees identified themselves in two or more sites on the map: as a parent and an expert, or as a parent, an expert and EE committee member. The following excerpts are from an interview with M' – a parent who suggested various "collaboration locations".

I had three kids in school, so I helped a group of kids who studied birds of prey with my older son (classroom project, R.T). I mentored a group of kids in the Industry

> *Project with my second son. I was asked to assess projects as an expert in another year, and I have been participating in the EE committee since we started it, so I guess I am everywhere on this map. Does it mean I do too much?*

Another parent, T', acknowledged her contribution only as a mentor in the Industry-Environment Project. She addressed the issue of potential fatigue, and suggested another circle in the map.

> *The first and maybe last time I was involved, I'm joking of course, was with the Industry Project. It was so intensive and so demanding that I need sometime, before my next volunteer work at school. However, this map is not accurate enough. I attended many other activities and was aware of what was happening, but with less involvement. I would add another circle to this map, which symbolizes awareness.*

Other involved parents did not agree with T'. The major claim was that parents can be either observers or participants and the aim was to draw a participation map.

The detailed description of the collaboration events allows to present the advantages and limitations of school-community collaboration as expressed by the participants.

Advantages and limitations

Although most of the interviewees in both stages spontaneously addressed pros and cons for community-school collaboration, they were requested to critique the collaboration efforts. Most of them emphasized the advantages and addressed the philosophy of the community approach. However, they all discussed disadvantages and barriers for achieving an *ideal cooperation*. A summary of the advantages and limitations of school-community collaboration, which was raised by teachers and community members, is presented in Table 3.

Table 3. Advantages and limitations of school-community collaboration

	Advantages	*Limitations*
Teachers	Greater involvement of the	Ambiguity about different roles may influence professionalism.
	community in school life, support for reforms.	Positive involvement may end with interfering
	Many more intellectual resources.	
	Positive attitudes towards classroom experiments.	Time consuming.
	Expanding the learning into "real life experiences".	
Community members	Knowing more about school.	Time consuming.
	Understanding the educational language	"Easy solution" for complex management issues.
	Appreciating teachers	Confuse between different roles.
	Contributing for better education.	"Pressure" for volunteer work - you
	Being part of decision making.	don't always want to be involved.

Two of the interviewees, a parent and a teacher discussed the pros and cons of this partnership regarding the establishment of community of learners.

Parent: *I know that sometimes I wish I could refuse a school call for partnership. I am busy with my own work, and when I come home I don't wish to work again. On the other hand, I know that my involvement causes our family to discuss schoolwork, and I'm sure it helps my kid to learn. The fact that he can share his new knowledge with us, who understand the context of the activities help him a lot. We feel that we know what he does in school, and we know what the demands and the assessments are going to be like.*

Teacher: *I expect the parents to be involved in the learning processes. I believe that parents who are more involved can help their kids better and share the same knowledge about school with them. My experience shows me that when parents and kids speak the same language either about learning or about projects and assessment, it helps a lot... I like to get parents' feedback on learning activities because these parents become part of the learning process in class.*

Although neither the teacher nor the parent used the professional term "community of learners" they both imply to the ideas of community of learners, or knowledge building communities.

Students' ideas may sometimes be different than those of the adults. Although two of the interviewed students were concerned about frequent meetings with their parents in school, others emphasized the positive aspects of parents' involvement.

SUMMARY AND DISCUSSION

Collaboration between a school and its community is subject to continuing discussion. It has clear advantages such as agreement upon educational goals and means. It also allows better management of resources (Sharan et al., 1999). Students and their families believe they are affecting the school's agenda. Parents also feel that school enhances their children's comprehensive experience in real life settings. Teachers who attempt to introduce reform feel encouraged by the community at large.

Students' achievements are an important issue that is brought to the forefront by educators as well as by community officials and politicians in many countries. Gray (1984) suggests that volunteer involvement in schools positively affects achievements, as well as the general atmosphere, which contributes to a better environment for achievements. Most of the interviewees described in this paper never raised the issue of achievements, although they addressed other learning advantages. Their perception is supported by Walberg (1984), who agrees that school-parents partnership may contribute to better achievements, but emphasizes other constructive roles of parents in school programs: parents as audience for schoolwork, tutors and co-learners. He claims that community members may contribute to school improvement much more than to achievements. In this study, both parents and students emphasized support, co-learning and shared responsibility towards school improvement.

Discomforts and sometimes frustration of partners accompany all these payoffs. These discomforts may be grouped under the title of role-play and leadership. Parents sometimes feel that they are the initiators, while teachers are not doing their job. The school's faculty may feel intimidated by various forms of parental interference. Phillips (1997) argues that although the communal organization seeks shared values and activities, positive social relations with adults in general and with teachers in particular, are hard to achieve. A possible way to discuss these discomforts would be in the context of developing discourse within learning community. Parents even addressed the development of common language as one of the advantages of this collaboration.

Lave (1988, 1991) suggested that schools fail because of creating artificial practice and environment, which is isolated from real life experiences, where people of different ages and expertise interact and solve problems. Lave perceives learning as an activity of the mind that constituted by visible social interaction that takes place among members of a community. "Cognition observed in everyday practice is distributed – stretched over, not divided among – mind, body, activity and culturally organized settings." (Lave, 1988, p.1). Bransford, Brown and Cocking (1999) address the importance of learning within communities: a family as a smaller community, which engages children in learning and acquiring skills as well as the broader community.

Connections to experts outside of school can have positive influence on in-school learning because they provide opportunities for students to interact with parents and other people who take an interest in what students are doing. It can be very motivating both to students and teachers to have opportunities to share their work with others. The intensive collaboration presented in this paper addresses both Lave's critique and Bransford's and colleagues recommendations. Accepting parents and community members as partners in the educational endeavor may contribute to better learning in real world context, and shared responsibilities in the educational process. Shulman (1997) argued that in order to promote successful collaboration both parties should see education as a systemic endeavor. In this effort disagreements and public debates may be part of any beneficial negotiation, especially when trying to establish a wide perception of the community's role in education.

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The Role of Press in Public Perception of Scientific Issues: The Case of the 'Greenhouse Effect'

K. Dimopoulos, *cdimop@eexi.gr* and V. Koulaidis, *koulaidi@upatras.gr*
University of Patras, Greece
V. Christidou, *ilia@the.forthnet.gr,* University of Thessaly, Greece

INTRODUCTION

The aim of this paper is to compare the way Press covers the issue of the Greenhouse effect with the children's and adults' ideas about the same phenomenon. This comparison will enable us to decide about the role of Press in public perception of scientific issues which are either not taught or in the best case are poorly taught in the formal educational system.

During the last two decades there has been an increasing public awareness and concern about environmental issues with global dimensions. Global warming due to the 'man-made' or enhanced greenhouse effect is one of the most important and large scale environmental threats that the Earth faces. Thus, there exists a growing need for information resources if citizens are to develop an adequate understanding of this environmental problem.

Effective planning, decision making, and action, both at a social and at a personal level require that citizens develop an adequate understanding of what the greenhouse effect is: its scientific mechanisms, its main causes, and its effects. On the other hand, misconceptions and misunderstandings concerning the causes and mechanisms of the greenhouse effect may influence decision making, leading people to take ineffective actions.

Some crucial questions arise: What do people know about the greenhouse effect? What more do they need to know at the level of scientific information? What are the most critical obstacles preventing public understanding of the greenhouse effect?

Recently, several papers have appeared in the literature regarding different groups' conceptions of the greenhouse effect. Recent research has revealed that children's as well as adults' views of global warming involve some similar and apparently persistent misconceptions. Regardless of age, people have problems in understanding and explaining the mechanisms of the greenhouse effect (Francis, Boyes, Qualter & Stanisstreet,1993, Boyes & Stanisstreet, 1993, Bostrom, Morgan & Read, 1994, Rye, Rubba, & Wiesenmayer, 1994, Dove, 1996 and Christidou, & Koulaidis, 1996).

We hypothesize that the way Press and mass media in general present the 'Greenhouse effect' influences the way that both adults and children think about it.

The 'Greenhouse effect' is a unique case study in order the impact of Press, not only on the formation of attitudes (a well researched area) but also of the public ideas about scientific phenomena well beyond the everyday experience, to be understood.

This uniqueness of the 'Greenhouse effect' is based on its following three characteristics:

a) The 'Greenhouse effect' entered the public arena with great intensity at the end of the eighties mainly through the press coverage and secondarily through the rest of the mass media coverage.

b) The 'Greenhouse effect' even today has not yet been fully included in most of the National Syllabuses of the Physical Sciences of the various countries.

c) Substantive amount of research has been carried out that revealed that both public and the students hold more or less quite similar ideas about this phenomenon.

These three characteristics make the hypothesis that Press shapes the public ideas about the 'Greenhouse effect' quite reasonable.

THE IMPACT OF PRESS ON THE WAY THE PUBLIC THINKS ABOUT SCIENTIFIC ISSUES

In order to conceptualize the problem of the interactions between the Press and the public, a review of all the relevant literature would reveal that two are the prominent models with all their variances that provide a satisfactory framework.

The first of these two models namely, the 'transfer model', has its origins in the most outdated linear and hence rather simplistic communication models. According to this model the only emitter of all the scientific issues that reach the public is the scientific community. Press plays the role of a simple mediator that merely translates, simplifies, or as is more generally mentioned, popularizes the scientific content.

Finally the public is considered as a passive ignorant and undifferentiated mass of people. This model suggests a superior role to the scientific community relatively to the public, an unproblematic image of the science emitted by it, a mere mediating role for Press and a passive character of the public (see fig.1)

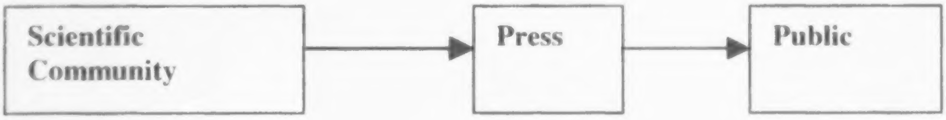

Fig. 1

The corresponding theory that seems to accommodate this linear, unidirectional model is the theory of the agenda-setting function of Press. According to this theory the frequent exposure to an issue presented by Press results in creating similar cognitive structures to most of the recipients (Brosius and Kepplinger, 1992). Thus this theory predicts that Press has strong short–term effects upon public. The strength of this effect depends on a number of factors such as:

a) the 'career' of an issue in the public domain,

b) the intensity of coverage and

c) the sensitivity of the recipient (Downs, 1972, Hilgartner & Bosk, 1988).

There is a broad agreement among the researchers that the agenda–setting effects of Press are stronger for issues that are new on the media agenda, have reached at the *peak of their coverage* and *sensitize the public* stirring a great level of public concern.

The second more elaborate and closer to reality according to our opinion model that tries to describe the Press–public relationship is the 'active process model'. According to this model the interaction is bi–directional in character. Press not simply mediates the scientific information emitted by the scientific community but also shapes it, changing some of its most critical features before reaching the public though a typical Press function called 'framing'.

By the term 'framing' we mean that the media discourse can be conceived of, as a set of interpretive packages that give meaning to an issue. According to Gamson and Modigliani, 1989, a package has an internal structure. At its core is a central organizing idea, or frame, for making sense of relevant events, suggesting what is at issue. *'Media frames' are 'largely unspoken and unacknowledged, organize the world both for journalists who report it and, in some important degree, for us who rely on their reports'.*

This part of the second model does not differ drastically from the linear model unless that it recognizes that Press has a more active role than that of a simple mediator in transmitting the scientific knowledge from the scientific community to the public and that the media frames have long term rather than short term effects on the way the public thinks about science. The important though, epistemological in nature gap of this model to the linear one, is that it acknowledges the active role of public in setting issues in the public arena which are then picked up and covered by the Press. In this case Press loses its leading role and becomes a reflector of the public beliefs, concerns and attitudes. This reverse direction of the agenda function process applies mainly in cases where the public has culturally or through direct experience preformed ideas or attitudes about specific issues (e.g. birth control, in vitro fertilization, risk issues, etc). In general this model predicts that the agendas set by the scientific community are shaped (some members of the scientific community would say distorted) by Press before reaching the public and are then renegotiated drastically within the different social contexts before being picked up again by the Press during a positive feedback process (see fig.2). This model has its origins in the theory of social constructivism.

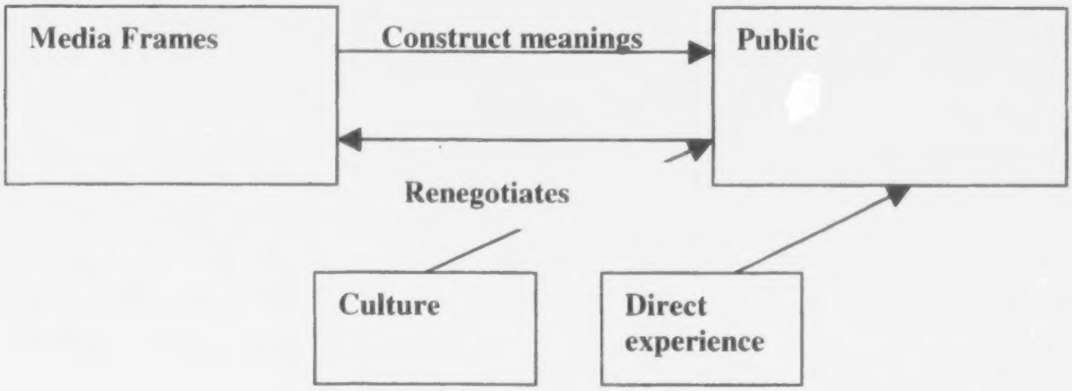

Fig. 2

HOW PRESS PRESENTS THE ‘GREENHOUSE EFFECT’

Press apart from the sociopolitical contexts within which the problem is discussed, offers also explicitly or implicitly some explanatory models to the public on technical aspects of it so as the public to be able to understand its mechanisms, its causes and its effects.

In terms of the greenhouse effect *mechanisms* Press presents two dominant models. According to the first model the sun’s rays are allowed into the Earth’s atmosphere but carbon dioxide forming something like a huge cap around the planet prevents them from escaping back to space hence leading to a global warming.

The second mechanistic account of Press is that climate change is caused by increased sun radiation entering due to the ozone ‘hole’ (stratospheric ozone depletion) which is then trapped by the carbon dioxide layer. Obviously this model stems from a very usual confusion created by Press that tends to relate stratospheric ozone depletion with the greenhouse effect. As Read et al, 1994 mention *‘one reason for this confusion may be that popular articles often discuss both problems together. Even when writers conscientiously distinguish between the effects, the very fact of frequently hearing about them simultaneously may lead people to form an association between them’*.

As far as the greenhouse effect causes are concerned, Press usually presents the following factors as the main contributors or creators of the problem:

- the CFCs
- the combustion of fossil fuels (automobile use, industrial emissions, etc) releasing carbon dioxide to the atmosphere
- miscellaneous natural sources (volcanic eruptions, burning of large tropical forests) of carbon dioxide emissions and other greenhouse gases (methane) and
- various other air pollutants.

The reference to the CFCs as a main contributor to the greenhouse effect (CFCs are indeed substances contributing to the greenhouse effect) is probably rooted to the misunderstanding of Press as described before in the second model.

Press presents the most significant cause of the greenhouse effect, which is carbon dioxide, emitted mainly by human activities, but this is blurred in the public mind for two main reasons:

1) The frequent reference made to the CFCs as a cause of the problem might create to the public the wrong belief that it is at least as equally important as carbon dioxide is and hence may lead as Bostrom et al, 1994 say *'laypeople to waste their energies on ineffective actions, such as conscientiously refusing to use spray cans, while neglecting such critical strategies as energy conservation'*;
2) Press presents the greenhouse effect and the ozone layer depletion issues together with other environmental problems thus causing a general blurring of the phenomenon.

One of the most prominent aspects of the problem illuminated by the Press is its *effects*. The generally observed tendency of Press is to maximize the magnitude of the effects and to treat them as local despite the fact that they are global in nature. Press emphasises the following consequences of the greenhouse effect:

1) A rise in the global temperature (global warming).
2) A rise of the oceans' level due to melting of the polar ice caps and also due to the thermal expansion of the sea water
3) Increased risk for health effects (skin cancer, sunburn)
4) Ecosystem impacts.

As far as the first consequence is concerned Wilkins, 1993 has discovered that there is a distinct coverage pattern within each year in the American Press. The number of the greenhouse stories rises with the atmospheric temperature. More than half of the greenhouse stories appear in April through August. If this fact is combined with the local rather than global in nature way that the problem is framed then two important inaccurate beliefs produced by the Press can be explained. The first of these two ideas is that the rise of the Earth's temperature is already *a fact* whereas the second idea is that the greenhouse effect affects the local weather rather than the global climate. Finally the risks of flooding and of dangerous health effects, are amplified by Press since as 'bad news' are by definition picked up as newsworthy.

PUBLIC UNDERSTANDING OF THE GREENHOUSE EFFECT: THE MAIN MISCONCEPTIONS

The public understanding of the greenhouse effect involves important misconceptions. The general public seems not only to have formed relatively stable mental models about the phenomena of 'greenhouse effect' and of 'ozone layer depletion' considered as interrelated, but also to use them in a quite consistent way. These misconceptions found in the relevant literature can be summarized as follows:

1. Every form of pollution is linked to every environmental problem. Thus, global warming can be seen as a consequence of using leaded petrol, dumping rubbish in rivers, or producing radioactive waste
2. Ultraviolet rays are extremely hot and can change the climate (Francis, Boyes, Qualter & Stanisstreet,1993, Boyes & Stanisstreet, 1993, Bostrom, Morgan & Read, 1994)
3. The primary cause of the greenhouse effect is ozone depletion. Thus, CFC's play a significant role in global warming, since they destroy stratospheric ozone
4. Heat is being trapped in the atmosphere by the ozone layer.
5. The greenhouse gases are considered to be concentrated in a thin atmospheric layer, found at a high altitude. This misconception could be enhanced by metaphors such as 'glass', or 'cover' often used to describe the role of these gases.
6. Solar radiation is being trapped near the ground because it weakens while traveling through the atmosphere ((Francis, Boyes, Qualter & Stanisstreet,1993, Boyes & Stanisstreet, 1993, Read, Bostrom, Morgan, Fischhoff & Smuts, 1994, Koulaidis and Christidou, 1996, Bostrom, Morgan & Read, 1994).

PUBLIC UNDERSTANDING OF THE GREENHOUSE EFFECT: EXPLANATIONS AND MODELS OF THINKING

As we have already stressed, perhaps the most salient characteristic of the public understanding of the greenhouse effect is that it is being confused with the ozone layer depletion. Researchers have proposed that people might intuitively confuse the greenhouse effect with ozone depletion because both phenomena:

i) involve solar radiation,
ii) involve CFC's and ozone (tropospheric or stratospheric),
iii) are global, and
iv) have gained publicity at the same time.

However, as we have seen in the previous section, people's explanations often involve more misconceptions than the confusion, or consolidation of the two phenomena. These misconceptions are embedded in structured mental models used in order to understand and explain the greenhouse effect. The mental models people use in order to explain complex scientific processes involved in the greenhouse effect can be fairly elaborate. Students' views on the other hand, present remarkable similarities with those of adults concerning the mechanisms of the greenhouse effect. The following alternative models of thinking have been recorded by researchers:

a) the greenhouse effect and ozone depletion are regarded as one phenomenon
b) heat is being trapped by ozone layer
c) the greenhouse gases filter the sun's rays

d) the greenhouse gases trap 'weak' solar radiation

e) the greenhouse effect is causally linked to ozone depletion

The greenhouse effect and ozone depletion are regarded as one phenomenon

The confusion of the greenhouse effect with ozone depletion is a prevalent characteristic of students' and adults' thinking. According to this explanation, ozone depletion allows more sunlight to penetrate the atmosphere and warm the Earth. Similarly, research on students' views has yielded the following detailed mental model that confounds the two phenomena (Koulaidis & Christidou, 1999):

Model of thinking

The ozone layer stops ultraviolet rays coming from the sun, preventing it from reaching the Earth. It is being destroyed by CFCs, gases used in refrigerators and spray cans. From the ozone holes more ultraviolet radiation can enter the atmosphere (see fig.3). This type of solar radiation is extremely dangerous for the human health, as well as for all living things. Additionally, ultraviolet rays are extremely hot, so they can raise the Earth's temperature and affect its climate.

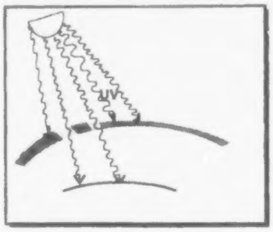

Fig. 3

Heat is being trapped by the ozone layer

This explanation attributes the role of 'filter', or 'glass', or 'cover', not to the greenhouse gases found in the troposphere, but to the ozone layer, which traps heat coming in from the sun, causing global warming. This view, which is reflected in the following model, can be regarded as an elaborated version of the previous model, as it gives the ozone layer the additional role of blocking the outgoing ultraviolet radiation.

Model of thinking

Ultraviolet rays enter the atmosphere from the ozone holes. This radiation is being trapped in the atmosphere by the ozone layer and so it remains near the ground (see fig.4). Ultraviolet radiation is very strong, hence very hot, so it can warm up the planet.

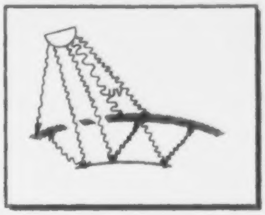

Fig. 4

The greenhouse gases filter the sun's rays

According to this view, the greenhouse gases act like a filter, or an one way mirror, letting sunlight in, but preventing it from escaping back to space. Quite often, children's mental models involve information about the distribution of the greenhouse gases in the atmosphere.

Model of thinking

Carbon dioxide and/or methane are gases found in the atmosphere. These gases are described as forming a thin layer at a certain altitude around the Earth. This layer acts like a huge glass, which lets the sun's rays in, but prevents them from escaping back to space (see fig.5). The greenhouse effect may raise the Earth's temperature and change its climate.

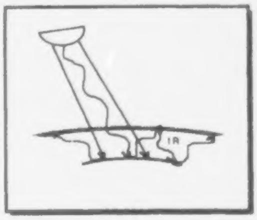

Fig. 5

The greenhouse gases trap 'weak' solar radiation

This view is an elaborated extension of the previous explanation. The sun's rays 'weaken' as they travel through the atmosphere and so they cannot travel all the way back, and remain into the Earth.

Model of thinking

The incoming sunlight reaching us from the sun, is 'strong' and so it can penetrate the carbon dioxide – methane layer. However, the sun's rays weaken as they travel across the atmosphere, and so the outgoing radiation is not strong enough to cross the layer again and escape to space (see fig.6). The heat from the sun that is being trapped near the ground causes global warming.

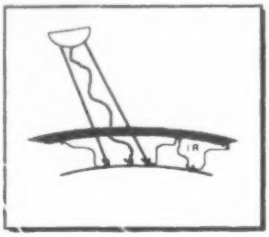

Fig. 6

The greenhouse effect is causally linked to ozone depletion

Apart from confusing global warming and ozone depletion, people may view the latter as the primary cause of the former. Increased ultraviolet radiation entering the ozone hole(s) is thought of as being trapped by greenhouse gases found in the atmosphere, raising the Earth's temperature.

Model of thinking

Methane and carbon dioxide form a thin layer in the atmosphere, at about the same altitude as the ozone layer. Ultraviolet radiation, which enters the ozone hole(s), is being trapped in the form of heat by the methane – carbon dioxide layer (see fig.7). This causes the Earth's temperature to rise and may result in severe climatic changes.

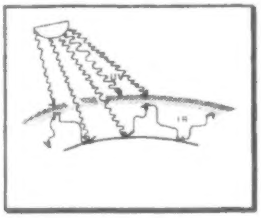

Fig. 7

Finally as far as the effects of the two phenomena are concerned the researchers (e.g. Bostrom, Morgan, Fischhoff & Read, 1994 and Dove, 1996), have found that both students and adults believe that:

a. The Earth's climate will be affected in the sense that the mean temperature of the planet will be increased and that unusual climatic phenomena in frequency and intensity will increase;

b. Polar ice will start to melt, the sea level will rise and many inhabited regions may be flooded;

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c. Some serious health risks like sun–burning, skin cancer, etc can arise and;

d. Some species may become extinct as a result of the new climatic conditions.

CONCLUSIONS

The way Press presents the greenhouse effect as well as the ozone layer depletion definitely shapes the way laypeople think about them. In this section we will attempt to present in a comparative fashion the way the scientific community, the Press and the general public think about the mechanisms, the causes and the effects of the greenhouse effect so as to show the connections between the perception of the general public and the way Press treats this phenomenon.

In Table.2, summarizing all the relevant research findings, we show the positions that the scientific community, the Press and the members of the public (Students+Adults) have about the mechanisms, the causes and the effects of the greenhouse effect and the ozone layer depletion respectively. The lighter colour code represents the positions that the scientific community, the Press and the public have in common, whereas the darker colour code represents the positions that only the Press and the public have in common.

This table reveals that newspaper stories have little effect in helping the members of the general public to understand the physical mechanisms that generate the 'greenhouse effect' and ozone layer depletion. Moreover, Press seems to produce distorted models of thinking about the two phenomena since they are mostly journalistic practices (newsworthiness, proximity, mis–emphasis) rather than scientific ones (accuracy, presentation of research findings) that frame the presentation of the two issues.

On the contrary Press seems to succeed to a large extend in identifying the right (as expressed by the scientific community) causes and effects of the greenhouse effect (see Table 2). This can be attributed to the great emphasis these two aspects of the phenomenon receive especially when the issue moves from the science sections to the political, economic and other sections during the politicalisation phase into which the issue has passed since the beginning of the nineties.

During this latter period of the press coverage of the issue the emphasis has been shifted towards the impacts of the two phenomena on human lives both at a social (industrial production, standards of living) and at a personal level (health risks, global warming). The media sources are not only scientists any more but also other social actors (environmental groups, pressure groups, concerned citizens, decision makers etc) who have entered the public discourse through the media and shaped the two issues focussing mostly on the issues' causes and effects.

In conclusion, Press fails to present a 'consistent to scientific' mental model to the laypeople, but on the other hand is proved to be very effective in focusing on the causes and effects of the scientific phenomena

Table 2: A comparative study between the scientific, the Press and the public beliefs about the mechanisms, causes and effects of the Greenhouse effect

	Mechanisms	Causes	Effects[1]
Scientific Community	• The greenhouse gases in the troposphere prevent terrestrial radiation from escaping to space	• Carbon dioxide emissions due to human activities	• Global warming
		• Carbon dioxide emissions due to natural phenomena	• Climate change
	• Ozone depletion is due to a decrease of the ozone concentration, as ozone is destroyed reacting chemically with the CFCs.	• Methane	• Rise of sea level
	• The two phenomena (greenhouse effect and ozone depletion layer) are completely distinct	• CFCs	• Health risks
			• Major changes in ecosystems
Press	• The greenhouse effect and ozone depletion are regarded as one phenomenon	• Carbon dioxide emissions due to human activities	• Global warming
		• Carbon dioxide emissions due to natural phenomena	• **Weather change**
		• CFCs	• Climate change
			• Rise of sea level
			• Health risks
			• Major changes in ecosystems
	• The greenhouse effect is causally linked to ozone depletion	• Various air pollutants	
	• Heat is being trapped in the atmosphere by the ozone layer	• CFCs	
		• Carbon dioxide emissions due to human activities	
	• The greenhouse gases trap 'weak' solar radiation	• Carbon dioxide emissions due to natural phenomena	
		• Nuclear power	
Students + Adult	• The greenhouse effect and ozone depletion are regarded as one phenomenon (S+A)	• Various air pollutants	• Global warming
	• Heat is being trapped by the ozone layer (S+A)		• **Weather change.**
	• The greenhouse gases filter the sun's rays (S)	• CFCs	• Climate change
	• The greenhouse gases trap 'weak' solar radiation (S)		• Rise of sea level
	• The greenhouse effect is causally linked to ozone depletion (S+A)	• Carbon dioxide emissions due to human activities	• Health risks
		• Carbon dioxide emissions due to natural phenomena	• Major changes in ecosystems
		• Nuclear power	

(1) Press and public tend to describe the effects as more intense as they are in reality and also to consider them as local while they are global in nature.

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A Cross-Age Study of Pupils' Conceptions Concerning the Movement of Air Masses in the Troposphere

Vasiliki Papadimitriou, Univ. of Thessaly, Greece, *vaspapad@uth.gr*
Paraskevi Londridou, Univ. of Thessaly, Greece

ABSTRACT

Since weather plays an important role in many ways in our everyday life, the study of meteorological phenomena by school children becomes of great importance in enhancing their scientific literacy. This necessity becomes even more important today, as these phenomena are connected to serious environmental problems such as climate change and air pollution. The reported research deals with the investigation of children's conceptions about the movement of air masses in the troposphere, as this movement constitutes an important factor in the generation of the meteorological phenomena and the dispersion of air pollutants. Thirteen children from 12 up to 18 years old were interviewed by using a semi–structured questionnaire. From the analysis of their answers it was found that the children of all ages had difficulties in explaining the mechanisms of movement of air masses in troposphere. Moreover, it was found that they held many misconceptions concerning the role of science concepts such as density, pressure, temperature, heat and forces in connection with the motion of air masses in the troposphere. Also, it was found that in their explanations they don't use knowledge taught in school, and that in the construction of their ideas about these issues, a vital role, played by their sensations, the mass media as well as a utilitarian consideration.

INTRODUCTION

For the last two decades it has been widely accepted by the science education community, that students hold ideas about science concepts prior to teaching which are usually inconsistent with scientific thinking. These initial ideas play a significant role in learning and for that reason they should be seriously taken into account in science teaching for meaningful learning to occur (i.e. Osborne, 1987, Driver, 1985). Today a considerable volume of research evidence exists on students' understanding for almost all areas of science.

An increasing number of these studies have been focused on pupils' understanding about the atmosphere, the climate, the meteorological phenomena in general (i.e. Stepans et al. 1985, Aron, et al 1994, Spiropoulou et al., 1999). Part of this research concerns pupils' understanding of environmental problems connected to the atmosphere such as global warming, acid rain and ozone layer depletion (cf. Dove, 1996; Rye et al, 1997; Boyes et al, 1993). Dove (1998) and Henriques (2000) reviewed the research into students' alternative conceptions about these phenomena. According to research evidence it seems that concepts relating to weather are constructed by children from their pre-school age and in this construction significant role is played by their senses, their fantasy, and expressions used by adults (Stepans et al. 1985). The research arrived also at conclusion that older children and adults have misconceptions too about the concepts and phenomena connected to meteorology (Nelson et al, 1992) which, among others, may have to do with inadequate ways of teaching about these at school.

Without any doubt teaching about meteorological phenomena is a difficult task, because these are very complicated systems and in advance, its understanding requires familiarisation with many science concepts such as the nature of gases, air pressure, dispersion, density, temperature, water cycle, etc. But, because of the significance of these phenomena in our everyday life, their study by school children becomes of great importance especially nowadays as these phenomena are connected to serious environmental problems such as climate change and air pollution. Thus, it is a challenge for educators to search for more proper ways of teaching about these phenomena and being aware of students' misconceptions they can invent effective methods for teaching.

The reported research constitutes the first step of a larger project aiming at the investigation of pupils' conceptions about the atmosphere, and the meteorological phenomena in connection with air pollution and climate change. We hope that the research findings will offer us an insight into students' thinking so as by taking this into account, we will be able to make suggestions which may help teachers in teaching about these issues.

BACKGROUND AND PURPOSE

In Greece, up to know, topics connected to meteorology are mainly taught in the primary and lower secondary school but not in the upper secondary school. Topics taught are: the structure of the atmosphere, the atmospheric pressure, the weather, climate and seasons, wind, water cycle, air pollution and its consequences. These topics are taught through Ggeography and Science.

A serious problem has to do with the ways these topics are taught. The Greek educational system is a strictly centralized and the school curricula are uniform, which means that not only are the same subjects taught but also the same contents, in the same order and also the same books are used in all schools. Teaching in all subjects has a theoretical character, takes place inside the classroom and even in science teaching children are not engaged in practical work. This is expected to have consequences in pupils' understanding in all areas of science including the topics connected to meteorology.

Many of the science concepts involved in the topics concerning the meteorology such as, the properties of gases, temperature, pressure, dispersion are also taught through science lessons but usually without making connections to these phenomena. In some cases these phenomena are taught before children have heard anything about the science concepts involved.

The study reported herein examined the different age children's perceptions a) about the movement of air masses in the troposphere and b) about the wind. The focus was the troposphere, as the movement of gases in this atmospheric layer is firmly connected, on the one hand with climate formation and on the other with the diffusion and the transportation of air pollutants.

This research conducted at the end of the school year and our main interest was to find out if pupils in explaining these phenomena use science knowledge that had been taught. We also included in our sample school leavers (18 years old) who as already mentioned had not been taught about meteorology during their study at the upper secondary school but they had been taught some of the involved science concepts.

SAMPLE AND METHOD

Thirteen pupils aged 12 to 18 years old constituted the sample of our research. More specifically:

3 pupils 12 yeas old (6th form of the primary school),

2 pupils 13 yeas old (1st form of the lower secondary school)

2 pupils 14 yeas old (2nd form of the lower secondary school)

3 pupils 15 yeas old (3rd form of the lower secondary school) and

3 pupils 18 yeas old (graduates of the upper secondary school).

These pupils interviewed by the use of semi-structured questionnaires. The questions had the same subject – matter but they were tailored to pupils' age and also to their responses in the previous questions. They were also asked to draw some pictures in order to illustrate their answers. Each interview lasted 15 minutes and was tape-recorded. We chose interview as the more effective methodology given that it helps in gaining an insight into pupils' way of thinking which we hope will guide us in the bigger scale research we plan for the future.

RESULTS AND DISCUSSION

As already mentioned the meteorological phenomena are complicated systems and many aspects concerning them are not even known to specialists. So we cannot expect school children to know all about these but what is needed is just some basic knowledge which will help them understand the way these affect their everyday life. Simplified scientific views concerning the issues under investigation can be summarised as follows: Air masses in the troposphere move, on the one hand because of the diffusion and on the other, by the creation of the wind. The movement of air masses may be horizontal or vertical. Horizontal movement (surface wind) always happens because of differences in pressure and temperature. The direction is from the low temperature and consequently of high pressure areas to high temperature and low pressure areas (Schlenker & Perry, 1981). Apart from the horizontal movement there is also the vertical one (air currents), downward and upward. A factor that also plays a significant role in the movement, is the topography. As more ruffles is land's surface as much turbulence and air dispersion takes place and so the vertical movement is easier (Cole, 1973). Also it is known that temperature inversions prevent vertical motion of air masses (Campbell & Gimps, 1975).

Children's conceptions about the movement of gases in the troposphere

In order to find out about pupils thinking concerning the motion of gases in the troposphere, we started interviewing pupils by asking the following questions: (a) Do you think that the gases that exist in the troposphere move? (b) If you think so, to which direction this movement takes place? And (c) what causes this movement?

We have to mention here that before starting the discussion with pupils it was made clear that troposphere is called the lower layer of the atmosphere.

From the analysis of children's responses to the first two of these questions it was found out that children of all ages were aware of the movement of gases in the troposphere and of the fact that this movement occurs to all directions. Concerning the causes of that movement, from their answers to the third of the above questions, it seems that they regard the wind as the cause of that movement which means that they think of it as something different from movement of air masses. The same was identified later on, when they were asked about the wind and its generation. Nobody mentioned the diffusion. Only three pupils, two from second form of lower secondary school and one graduate of the upper secondary school, mentioned the verb "*spread*" but again they added the phrase "*with the wind*". The explanations they offered come probably from their sense experience, as the wind is something that they feel through their senses.

In our effort to have a deeper insight in children's thinking concerning the motion of gases in the troposphere, in the course of the interview, they were asked if they thought that among the directions the gases follow in their movement the vertical and the horizontal were included. After their positive answer to this question, they were asked to explain the causes of these movements.

From their answers it was found that all children with no exception, believe that the gravity is the determining factor that causes the vertical motion of gases of the troposphere. According to what they say it seems that they separate gases of the troposphere in heavy and light. Some typical answers run as follows:

> *"heavy gases go down and the lighter go up"*
>
> *"the light gases go up and the heavier go down"*
>
> *"gases move vertically because of the gravity".*

It also seems that this view is firmly hold in their mind as one can judge from the following dialogue. In the mind of this child the gravity plays so important role in motion that he precludes the horizontal motion of gases.

Quest. "Why gases go up? What causes this movement?"

Ans. "Because they are lighter"

Quest. "Does atmospheric air go down?"

Ans. "Yes, if gases are heavier. Yes"

Quest. "Does it happen horizontal movement?"

Ans. "I don't think so"

These conceptions concerning the role of gravity in motion of gases show that children hold misconceptions about the properties of gases. Other researchers too (Nelson et al, 1992) found that even university students in geography consider gravity as the only factor determining the movement of gases in the atmosphere.

Children's conception about wind and its generation

In this part of our research we focused in finding out: a) what pupils think about the wind and b) what explanations they give concerning the generation of the wind.

We have to mention here that pupils actually had taught about the wind and its generation in the 6th form of the primary school and also in the 1st and 2nd form of the low secondary school. In their textbooks it is mentioned the role of the temperature and pressure in the generation of the wind and also the role of the topography. Also they have taught about horizontal and vertical movement of air masses.

Views about the wind

Firstly pupils asked the question: What do you think the wind is all about? Apart from those who answered "I do not know", the answers of the rest fall into four categories which are presented in the Table 1.

Characteristic answers that fall in each one of the four categories are the following:

1) Those that give a scientifically acceptable answer mentioning both the constitution of the wind and the movement.

"Movement of air masses"

"The wind has some gases; it is made up of some gases and these gases go fast to a direction"

1) Those that think of the wind as the cause of the movement of air masses

"Gases that move when it blows"

"Movement of air masses occurs when air blows"

2) The majority described the wind mentioning properties perceived rather through their senses.

"The wind has a great force. It moves".

"Something that blows"

"The currents that exist in the environment"

3) Irrelevant overgeneralized answers: "*In my opinion it is a physical phenomenon*"

Table 1: Students' views about the wind

Categories of answers	Number of children divided in different ages				
	Primary school (3)	1st form of lower sec. school (2)	2nd form of lower sec. school (2)	3rd form of lower sec. school (3)	Upper sec. school graduates (3)
Scientifically acceptable answers		1		2	1
Think of the wind as the cause of the movement of air masses			1		1
Describe the wind mentioning properties perceived through their senses	1	1	1		1
Irrelevant answers	1				
No answer	1			1	

Views about the causes generating the wind

Children's responses to the second question in this part of our research concerning their explanations about the causes of the generation of the wind are summarised in Table 2.

Table 2: Students' answers in question about the causes of the generation of the wind

Categories of answers	Number of children divided in different ages				
	Primary school (3)	1st form of lower sec. school (2)	2nd form of lower sec. school (2)	3rd form of lower sec. school (3)	Upper sec. school graduates (3)
Connection with pressure and temperature				1	
Connection only with pressure			1		
Connection only with temperature		1			1
Connection with force	1		1		
Other answers	2			2	
No answer		1			2

As one can see from the table 2, only one child (3rd form of lower sec. School) relate the generation of wind to both pressure and temperature. In his words:

"*Warm air masses go up because the warmer they are the lighter they getting and so air blows upwards. As air masses go up, they become cold, and thus heavier and then air masses go down. The wind also flows from high pressure to low*".

Two children (one from 1st form of lower secondary school, and one of upper secondary school graduate), relate the wind to differences in temperature. In their answers they said that there is a movement of gases from low temperature areas to high temperature areas and they connect this motion with "north wind". From the answer given by the upper secondary school it seems that the TV weather forecasts play a significant role in constructing their views about the generation of the weather.

"As we hear on T.V news, on weather forecast, a warm stream of air will come from Africa and after a few days we have hot weather. Then they announce that a cold steam of air will come from North Pole and after that we have cold weather".

One student mentioned the pressure but it seems that he confuses it with the force. In his words: *"The wind is caused because of a pressure. This pressure forces the wind with a press to go to a direction. It will be pressed. The most it is pressed the more it blows, the least it is pressed the less it blows"* (2nd form of lower sec. school).

Two students, one from the 6th form of primary school and one from the 2nd form of lower secondary school mention the force. They talk about attractive force or force caused by heat.

"Some air masses attract others and so it creates the wind" (pupil from the 6th form of primary school).

"The wind has a big force. Heat pushes it. The heat has also a great force" (2nd form of lower sec. school).

The rest seven pupils, gave irrelevant answers or said: *"I don't know"*.

In conclusion, it seems that although pupils have taught in school about the role of pressure and temperature in the generation of the wind, finally their senses and weather forecasts on TV affect them in constructing their own views. It is also significant to mention the identified misconceptions such as confusing the air pressure with force and force with heat.

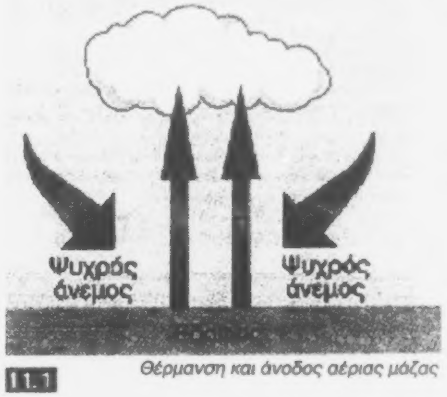


Fig. 1. Air movement between warm area and colder area nearby presented in school textbook.

In order to find out more about the impact had in their understanding, knowledge taught in school about the mechanisms the wind is generated, we asked them to draw a picture showing the directions of the wind between a town which is warm and the cold countryside nearby. They also asked to give some explanations. Taken into account that such pictures followed by explanations concerning the directions that air masses follow are contained in many of their science and geography textbooks for both primary and lower secondary school. In detail it is explained the role that pressure, temperature and density play in the generation of the upward currents, the downward currents and the surface wind.

By examining children's pictures, we identified that only in four of these the circular motion of the air masses between the warm city and the cold suburb is represented. From these pictures one drawn by a primary school pupil, two by 3rd and one by 2nd form of the lower secondary school pupils.

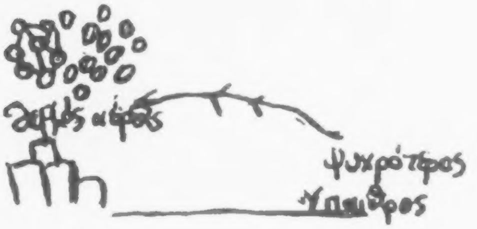


Fig. 2a. 1st form of low sec. school student's picture.

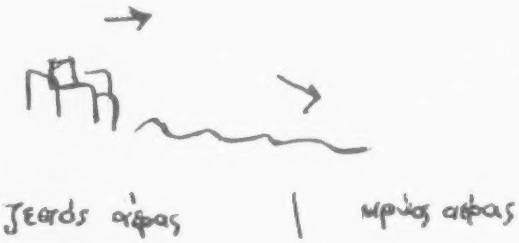
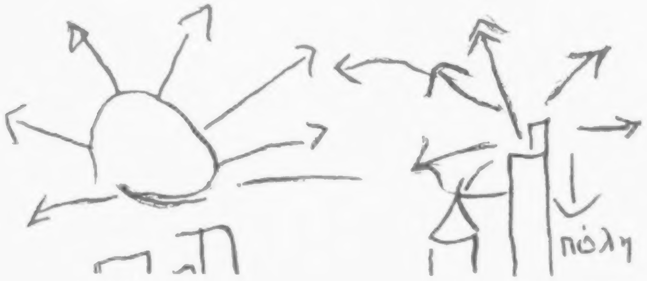


Fig. 2b. Primary school student's picture.

In another four pictures only the surface wind to one direction, from the country to the town or the reverse, is represented (Figure 2a, 2b). Finally in two pictures (drawn by upper secondary school graduates) surface wind is also represented as air current coming from opposite directions (Figure 2c).



Three children refused to draw anything with the excuse that they didn't know.

Concerning the explanations they gave about the causes of the movement presented in their pictures it was found that from the four children that drew the circulate motion only two student both in third form of lower secondary school were able to give explanations close to the scientific view. For instance by saying that *"the warm air goes up and by that it is getting colder, heavier and thus it goes downward"*. It seems that the mechanistic way of learning in their mind leaves only the figure of this motion but not the necessary scientific explanations.

The fact that, in all children's explanations concerning the causes of the movement of air between the city and the suburb, a utilitarian view is prevailing came as a surprise to us. They think that movement takes place under the necessity of "cleaning" the town of pollutants and bringing fresh, clean air from the countryside. Some of their answers are the following:

"The wind transports pollution from the town to the countryside, or clean and cold wind from country comes to the town so the town is getting clean" (pupil from primary school).

"The pollution from factories and vehicles causes the increase of temperature in the city so the wind from the city to the country takes the pollution from the city to the country, from hot place to the cold one." (pupil from 3rd form of lower sec. school).

The utilitarian view is more apparent in one upper sec. school graduate's response that seems to believe that air masses move in order to clean the polluted atmosphere of the city and its direction depends on the degree of air pollution of the city and the countryside.

"I believe that air masses go only from the city to the country. I don't know how exactly, it depends on the air pollution that is produced in the country, if there are factories there. If air above suburb is cleaner than above city I believe that, only in that case, air pollution from city will be transferred to suburb" (upper sec. school graduate).

This utilitarian consideration apart from not being compatible with the scientific views, may have an impact on pupils attitudes to the environment. They may think that people who live in the city can pollute as pollution disappears by the wind.

CONCLUSIONS AND IMPLICATIONS

Findings drawn from this small scale research concerning pupils' conceptions can be summarised as follows:

- Pupils of all ages, included in the sample, are aware of the movement of gases in the troposphere and of the fact that this movement occurs to all directions.
- PThe majority of pupils, independently of their age, separate gases into heavy and light and regard the gravity as the main factor of determining the vertical motion of gases.
- PMany of them regard the wind as something different from movement of air masses. They actually believe that the wind is the cause of that movement.

- Some describe the wind by mentioning properties perceived through their senses rather than using scientific terms taught in school.
- Pupils of all ages hold misconceptions concerning science concepts, such as the properties of gases, they confuse the pressure with the force and the heat with the force.
- The TV weather forecasts play a significant role in constructing their views about the generation of the weather.
- Their views concerning the movement of air masses between a city and the nearby countryside are guided mainly on the bases of a utilitarian consideration having to do with the transfer of pollution.
- In general we did not identified considerable differentiation in pupils' conceptions about the issues under investigation following the increase of their age. In the contrary in many cases younger children were more accurate in their responses than the older ones. It seems that further they are from the teaching about this theme the less they know about it. This is probably due to learning by rote, which is in fact the common practice in Greek schools.

These findings should be seriously taken into account in teaching about issues concerning the atmosphere, the weather, the climate, and air pollution. The content taught should be suitable for pupils' age avoiding the science concepts, which have not so far being taught. It would be of vital importance the use of these themes as contexts for teaching the science concepts involved. Also, involving pupils in practical work should be included in teaching and the use of new technologies will be an attractive way for learning and may contribute to better understanding. If the understanding of these important themes connected to the atmospheric phenomena, must constitute part of adults' scientific literacy, then teaching about them should not just stop at the level of the lower secondary school, but it must also be part of the upper secondary school curriculum.

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Alternative Methods of Evaluation in Environmental Education: The Use of Portfolio and Storyline

Aravella Zachariou, University of Ioannina,
aravellaz@hotmail.com
Chrysanthi Kadji-Beltran, University of Warwick,
edrda@yahoo.com

INTRODUCTION

As an educational approach, Environmental Education (E.E.) can be distinguished from other educational procedures by the fact that it focuses on inculcating and forming attitudes and values, which in the long run will result to environmentally aware citizens. This dimension, is probably not compatible with the current educational reality which emphasizes the reinforcement and expansion of the students' cognition. (Lozzi, 1984).

As far as E.E. is concerned, school reality faces new demands and expectations, oriented towards the promotion of environmental information and *"dynamic environmental qualities"* (Posh, 1994:21). In order to satisfy this demand, decision makers have to reconstruct and reorganize school structure and procedures and adjust them to the wider Environmental Education philosophy.

Many schools have applied this new educational structure by reorienting their school policy according to E.E. demands: promotion of environmental knowledge, skills and abilities that will lead students to environmental awareness and action for the solution of environmental problems. The organization and selection of educational approaches, methods, context and teaching material to be used for that purpose, poses a critical question about their effectiveness and appropriateness. So the planning of an educational programme, not only requires the determination of specific aims and targets, the choice of context and general outline, but also the inclusion of an evaluation plan which will provide information about the effectiveness of the elements of the Curriculum, mentioned above.

EDUCATIONAL EVALUATION FRAMEWORK

Evaluation is defined as the systematic application of social research procedures, in order to achieve an effective planning and application of a programme, as well as ensuring its usefulness. (Rossi and Freeman, 1998:615)

According to Kassotakis (1998:615), evaluation in education constitutes *"a procedure of checking the appropriateness, the effectiveness and functionality of all the elements of the educational procedure, as well as all its products and its relations with the wider educational and social system."* Thus, evaluation constitutes a solid element of the procedure for the improvement and development of the Curriculum. (Bennet, 1987:4).

School is the microcosm of society and through the curriculum it reflects the ideologies of the political and social status quo. Consequently, evaluation is adjusted to the same social characteristics: it is limited to marking and ranking as a response to the necessity for preparing working potential for the work market. Evaluation is degraded to a simple tool for gathering information about the student's cognition. Any other important qualities of his/her personality, acquired during educational procedures, are overseen. The current evaluation frame lacks the potential for formative evolution. Consequently it cannot fully support the reviewing, the improvement and the reorientation of the Curriculum according to the new facts and demands of society.

E.E. procedures, open school to the society and introduce students to problem solving procedures while at the same time, it develops their initiative and sense of responsibility towards a better world. Thus E.E. can be considered to be a powerful and innovative procedure. Its application requires urgent action for the adjustment of the educational system.

THE IMPORTANCE OF EVALUATION IN ENVIRONMENTAL EDUCATION

Evaluation is an important variable in the E.E. structure and as such, it is based on its philosophy and general framework. Thus it demands the use of procedures, other than the traditional ones. The mere assessment and evaluation of knowledge has to be reinforced with the provision of feedback and information for support and improvement. The new, holistic role of evaluation cannot function solely through the "evaluative judgment" of the educator, but it also requires the involvement of the student as an important contributor and participant of the educational process. For the case of E.E. evaluation constitutes a systematic criticism, oriented towards three essential axes:

- The improvement of communication among the educators and between them and the students along with the exchange of environmental experiences.
- Producing knowledge about the environment through environmentally oriented actions.
- The application of dynamic schemas that establish new environmentally oriented educational structures. (Posch, 1994:27)

Evaluation is an important means for diagnosing the acquisition of abilities and positive environmental attitudes and actions. The fact was also stressed during International Conferences, along with the establishment of the theoretical and methodological framework of E.E.: "…educational change is indispensable, for the facilitation of the incorporation of E.E. in the educational systems. It must be supported both by the experience and by their evaluation in order to improve the decisions taken over the educational policy. (Hellenic Association of E.E. Educators, 1999:36)

In spite of the fact that the importance of E.E. evaluation was stressed since its first presence in education, as probably the only educational approach that could respond to the new educational environmental orientation, it is still marginalized and still not explicitly defined and introduced in the curricula. The inability to define the characteristics that evaluation should have within the educational system, is a result of common obstacles, lack of time, complexity. The same obstacles are observed in E.E. and they result from the special character of E.E. which makes its organization and application through all the stages of the curriculum, difficult.

E.E. APPLICATION AND EVALUATION DIFFICULTIES

About the evolution of evaluation in environmental education, we can observe that it is characterized by "lack of strictness, which rarely offers substantial information for the improvement of the action". (Raptis, 2000:187) The vagueness and confusion can be explained by the complex and multidimensional nature of E.E. emerging from the following elements:

- Its interdisciplinary character
- The broadness of its targets, which do not only cover cognition but also cultivating abilities, values, attitudes as well as developing strategies, and participation mechanisms for action and resolution of environmental problems.
- The variety of teaching approaches and activities, that expand outside the classroom limits (UNESCO – UNEP, no9.)
- The principal target which stresses the development of positive environmental attitudes: an element difficult to measure and evaluate through the traditional evaluation instruments (Palmer and Neal, 1994)
- The fact that the environment is an important part of social action and part of every student's personal experiences.
- The new roles determined for educators and students: guide to the educational procedures for the former and active partnership to it by the latter.

An other factor, leading to evaluation's marginalisation concerns the lack of understanding, of the benefits that an organized evaluative procedure can offer:

A. The improvement of thee educational approaches and activities of the curriculum

B. The acquisition, by the student, of cognition development skills, as well as value examination, and practical action skills.

C. The reinforcement and support of the Curriculum so that it can be developed according to the E.E.

(Grover, 1991).

PAPER OBJECTIVE:

The present paper is a result of all the queries posed above. It attempts to examine a possible framework that could be applied for E.E. evaluation purposes. As a respond to the special character of E.E. it turns to special evaluation tools which have the potential and the flexibility to adjust to the topics' and the persons' particular needs. These tools incorporate elements, fit for the evaluation of E.E. variables such as students' personality and behavior.

This conclusion emerged from the examination of the general procedure of educational evaluation and the necessity for the initiation of new evaluation mechanisms that would facilitate the renewal of the traditional educational instruction. In particular, it is necessary to highlight the facts that:

- The evaluation of attitudes is a very difficult task given that: "we are not in the position to present a firmly established educational method of their measurement" (Decorte, 1990:303) The issues emerging from attitude evaluation do not only involve the difficulty for the creation of attitude measurement tools but also the inability of examining their duration too.
- E.E. actions are loosely evaluated though students' written reports about their behavior change along with some lists describing the programme's positive and negative elements. (Raptis, 2000:193)
- The concept of evaluation is often interpreted by the educators, as a tool for "selection and categorisation" which, in the school reality, occurs during the summative cognition tests the students are subjected to.

Evaluation cannot escape from this established outline and cannot respond to its real character, unless it becomes reconstructed and reshaped into a more flexible holistic and participatory function. This can be facilitated by educational contexts, such as E.E. E.E. could create the suitable conditions for the creation of measurement tools, able to provide to the educator the ability to offer to the students, feedback about the issue studied. It has a positive impact on student's self image and learning attitudes. It also constitutes a means of testing the effectiveness of the teaching approaches and materials used.

EVALUATION TOOLS FOR E.E.

The tools used for the student evaluation in E.E. must be reliable, objective, valid and practical for gathering information, in order to evaluate:

- The knowledge and understanding of environmental issues, concepts and problems
- The students' emotional conditions, about their attitudes and values
- Their skills for research, experimentation and communication
- Their abilities for decision making, and active participation privately or in groups, for the protection of the environment (UNESCO, no26.)

This paper will present two such evaluation tools, which precisely because of their broadness they offer a vast variety of possible uses and can be considered to be two very important tools for the evaluation of the elements, marginalised in the educational procedure. Portfolio and the story line method can be used for the evaluation of E.E. because these two tools can:

- Ensure the application of the E.E. principles; holism, globality and interdisciplinarity.
- Establish and reinforce, cooperation and interaction, in the teacher – student relationship.
- Provide opportunities for initiatives and experiential learning.
- Be flexible and powerful with respect to the studied issue
- Include numerous other research and evaluation tools along with teaching methods, in order to respond to the specific issue's demands

According to this reasoning, this paper will attempt to present the way in which these two tools can function as E.E. evaluation tools, through real primary education curriculum context. The evaluation will only focus on the student.

PORTFOLIO

Portfolio, is an evaluation tool that promotes effective learning and responds to the evaluation needs beyond the bureaucratic mechanisms and measurement scale based evaluation systems. (Lyon, 1998:20) It is an innovation for education, since it includes students' activities and projects both from school and personal work outside school. The student discusses with the teacher about the targets that should be met during the study and at the end, him/her self decides which activities and projects will be presented in the portfolio. These could be projects about the topic, photographs' collection, diagrams, reports, research projects, even dramatised presentations.

The important issue about using portfolios for evaluation purposes is that evaluation can easily acquire qualitative character and also includes elements of self evaluation, recognition and acknowledgement of self value. Students become actively involved in what they learn and they are responsible and in control of their education. They have the opportunity for cognitive development as well as personal and social development. The communication with the educator, for evaluation purposes, can provide a holistic image of the student, by revealing all his/her qualities.

STORY LINE

Story line constitutes the connection between a series of episodes within a narration line resulting to a story. Investigating an issue by means of the storyline approach, requires target specification in order to organise the materials and resources to be used.

There are several investigations that examine the effectiveness of the specific teaching method, which have revealed that it provides students with opportunities for skill development and active participation for the environment. (Heliopoulou, 2000).

In Story line, similarly to portfolio, the educator can use many of the common evaluation tools, such as the interview and questionnaire, in order to diagnose students' level of knowledge and experience on the topic as well as the modification of their initial position and attitudes about the topic. According to the group's potential and the way the teaching of the issue evolves, the teacher can also introduce more tools, that s/he considers appropriate for the development of skills, decision making and students' initiative. Activities such as dramatisation, role-play and panel discussions provide to the students opportunities for expressing their feelings and ideas as well as behave and act in a real life context. These cannot be provided within the traditional educational framework. The educator, on the other hand, can observe the student and in this way develop a holistic view of the students' abilities and qualities beyond the measuring molds of usual evaluation.

It is important that the educator, regardless the tool used, s/he has to have in mind a specific procedure which will facilitate the structure of an evaluation model. Initially s/he has to define and fully clarity the environmental issue to be studied and determine the aims and targets to be attained. These along with the careful organisation of the teaching procedures ensures a successful implementation of the issue and consequently the construction of an effective evaluation model.

The development of the two example models produced in this paper can be presented in the following diagrams.

The evaluation of the issue can be based on a number of important questions.

- Were the targets achieved?
- Was a variety of teaching activities and methodologies used?
- Was the nearby environment used for teaching purposes?
- Can there be observed any change in children's attitudes and behavior after the completion of the programme?

The evaluation tools used in the paper for E.E. evaluation are simple examples. They represent a general framework on which E.E. evaluation could be structured . They are extremely flexible and they could be reorganized and adjusted to include activities, according to the needs of the corresponding topic and students group and teaching conditions.

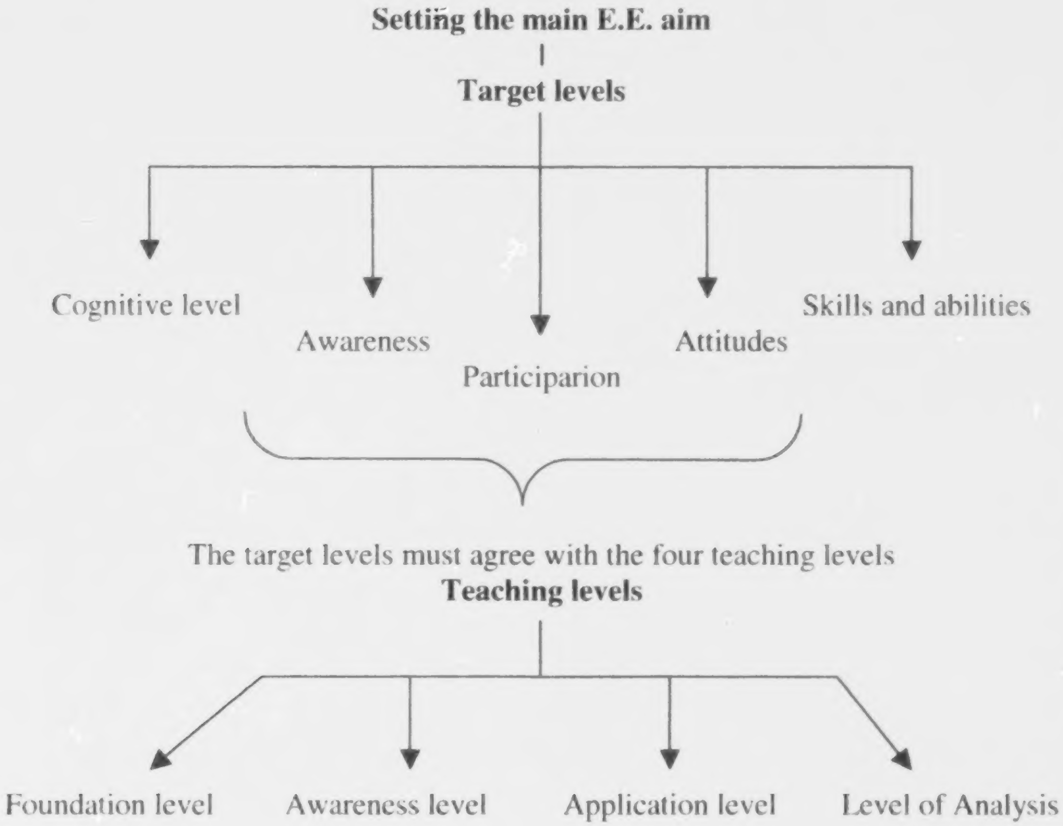
Setting the main E.E. aim
Target levels
Cognitive level
Awareness
Participarion
Attitudes
Skills and abilities
The target levels must agree with the four teaching levels
Teaching levels
Foundation level
Awareness level
Application level
Level of Analysis

Fig. 1. E.E. Evaluation general framework

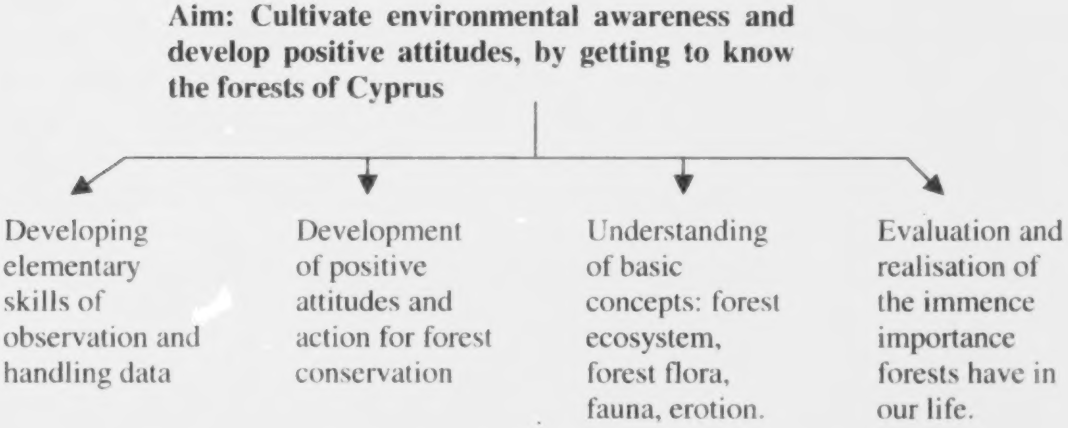
Aim: Cultivate environmental awareness and develop positive attitudes, by getting to know the forests of Cyprus
Developing elementary skills of observation and handling data
Development of positive attitudes and action for forest conservation
Understanding of basic concepts: forest ecosystem, forest flora, fauna, erotion.
Evaluation and realisation of the immence importance forests have in our life.

Fig. 2. Definition of the aim and targets for the topic "Getting to know Cyprus' forests" for portfolio construction.

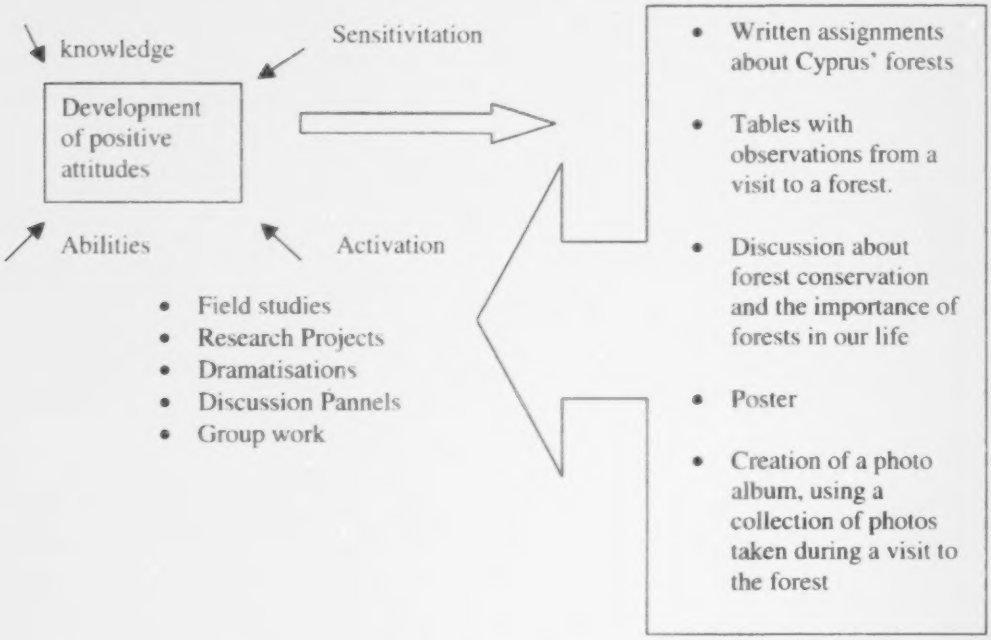
knowledge
Sensitivitation
Development of positive attitudes
Abilities
Activation
Field studies
Research Projects
Dramatisations
Discussion Pannels
Group work
Written assignments about Cyprus' forests
Tables with observations from a visit to a forest.
Discussion about forest conservation and the importance of forests in our life
Poster
Creation of a photo album, using a collection of photos taken during a visit to the forest

Fig. 3 Determining the teaching material and the criteria for the selection of the work to be included in the portfolio.

Topic: Getting to know Cyprus' forests				
Episodes	Questions	Activities	Targets	Resources Material
The episodes organized are connected to: -the functions of the forest as an ecosystem -the threats and dangers a forest faces -Woods conservation (all the episodes stated above can be organized in a story)	Which is the structure of the forest as an ecosystem? Which are the vegetation levels? Which is the importance of woods for the man? How can forests be protected?	Dramatisations Role play Excursions Woods field studies Data collection, observation and data processing and presentation of results Interviews Acting games Simulation games	The aims concerning the topic are mentioned above and they were developed according to the needs of the topic stated in the curriculum	Community involvement Access in various resources: books, charts, maps, pictures, archives…) Discussions Cooperation with forestry specialists

Fig. 4 Development of the Storyline model (Bell,1999). The initial structure of the method is similar to the one applied for the portfolio.

CONCLUSION:

The qualitative aspect of the evaluation, studied in this paper, although very rarely used, is very functional and powerful if applied through methods like the ones already described. The portfolio and the storyline methods prove that evaluation can help students acquire independence in learning, improve their personal development. They can prove their achievements by providing evidence which they create, they can participate in the teaching – learning procedure and finally they acquire self evaluation and metacognitive skills.

Evaluation is an indispensable part of the Curriculum and is directed towards the improvement and reinforcement of planning, development and application of all the teaching procedures.

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Percolation in Nature

Cilla Choresh, Bar Ilan University, Israel
choreshc@zahav.net.il

Percolation in Nature is a Learning Unit in which we describe a model that enables the student to investigate various systems in nature where percolation exists.

When we hear the term Percolation, our instinct leads us to water percolation. We are familiar with the Percolator, a home device for coffee preparing, in which the water steam percolates through the coffee.

Percolation is a model that describes disordered systems in nature (Bunde A., Havlin S., 1996). A disordered system is a system in which holes and material components are scattered in a random fashion.

Not only water can percolate. A blaze starts in the forest and the fire is spreading from tree to tree, is also described by the percolation model. A disease starts at a sick person infecting his close surrounding, which continues infecting people in the far surrounding, is also described by the percolation model. Even a computer virus that is transferred from one computer to another is also described by percolation.

To understand the principles of the model, let us define few terms:

In the Percolation Model our system is a lattice. We divide it by a net to cells which we call sites.

If we throw 100 seeds on a net sized 10x10=100 sites: Will a tree grow from each seed? Let's say it is a dry area and the chance for growing a tree is low.

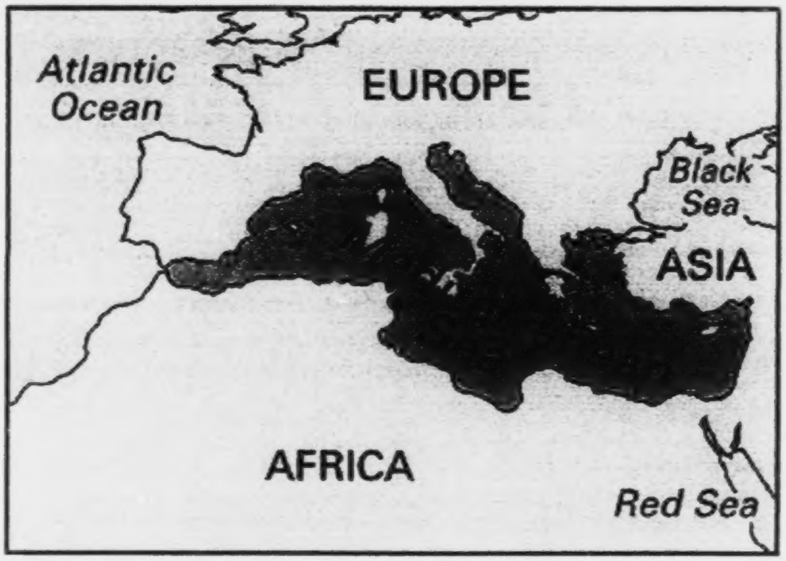
If we evaluate, on the past experience that in a certain area the probability for growing a tree is, for example 30%, can we determine, for sure, that from a 100 of seeds, will grow 30 trees? The chance, or probability, is a theoretically magnitude!

Eventually, the number of growing trees is proportional to the number of seeds in the lattice's sites and is defined as the lattice concentration.

If we throw wet sea sand on a certain surface, we see that mud blocks in various sizes cover the surface. These mud blocks is called in our model clusters.

In the following example, we demonstrate the connection between the number of clusters and their size:

Examine the islands in the Mediterranean Sea and answer the question:



- *Use the Atlas and name the five big islands in the Mediterranean Sea.*
- *Are there more big islands or small islands?*
- *Suppose the lattice stands for the Mediterranean Sea – what term in the percolation model describes the islands?*

We are interesting in a cluster that spreads from one side of the lattice to the opposite one. Such a cluster is called a percolating cluster.

The goal of the following task is to describe the nature of the percolating cluster:

In the following figure there is a percolating cluster in a squared lattice. The percolating cluster is in the colors of ***red*****,** ***blue*****,** ***green****, and white. Other clusters are* ***yellow****.*

Fill in the proper terms for the role of the colors (Use the bank bellow):

- ***Red:*** ____________________
- *White,* ***red:*** ____________________
- ***Blue:*** ____________________
- *White,* ***red, blue:*** ____________________
- ***Green:*** ____________________
- ***Yellow:*** ____________________

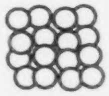
Bank: Backbone, dangling ends, red sites, blobs, non-percolating clusters, a possible track from one side of the lattice to the other.

In lattices with low concentration we will seldom find a percolating cluster. In lattices with high concentration a percolating cluster will be often found.

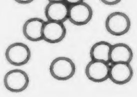
There are processes that we can characterize by percolation model, such as the transition of material from one state of phase to another in its critical temperature. This term is analogue to a term we call a critical concentration: This is the minimum concentration for filling, in which we get a percolating cluster in high probability.

The next example shows the connection between the percolation model and the transition of state of phase:

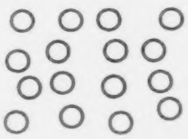
In room temperature, metals are usually in a solid state of phase, in which the atoms are very close each to the other:



When the metal is being warmed up gradually, it becomes red hot, and the atoms start to distant each from the other. At a certain stage, the atoms are far away each from the other, and the metal begins to be at a liquid state of phase. At this stage, which is called the melting temperature, there are solid regions and liquid regions:



If we keep on warming up the metal above melting temperature, it becomes a liquid state of phase:



The melting temperature, when we find a transition of a state of phase, is also called a critical temperature.

A solid state of phase changes to a liquid state of phase and vise versa in the critical temperature; part of the material will still be in a solid phase and the other part of it will be in a liquid phase.

Use the bank bellow to fill in the proper terms:

- *The critical temperature can be called in the percolation model* ______________________________.
- *Bellow the critical temperature the material will be in a* ________________ *phase.*
- *Above the critical temperature the material will be in a* _______________ *phase.*
- *Blocks of atoms in a liquid phase within a solid phase can be called in the percolation model* ______________________________.
- *In the critical temperature we are likely to find a* ____________________________.

Bank: Liquid, solid, critical concentration, percolating cluster, clusters in the critical concentration.

A study named "*The impact of teaching the subject of randomness on attitudes and scientific intuition*" has been performed in Bar Ilan University in Israel, under the supervision of Professor Joseph Menis and Professor Shlomo Havlin

'This study describes the development, implementation and evaluation of the effectiveness of the module (teaching unit) "Percolation in Nature". The main goal of the study was to evaluate this module, based on the concept randomness in nature and the transition from disorder to order. The aim is to find out how this module "Percolation in Nature" contributes to developing scientific intuition and attitudes toward science (Fishbein, E. & Gazit, A., 1984; Zablotskii, V. etal, 1992).

This particular module was developed within the framework of the program "Science and Technology in Society". This program is one of the recommendations of the Harrari Commission in 1993, and is published in "Tomorrow 98" (report) – a five years reform in Science and Mathematics. More specifically, the report recommends developing a variety of modules, each encompassing aspects from a range of scientific fields, technology, society, economics and environment. These modules aim at high school students who choose not to major in the sciences.

In the teaching unit "Percolation in Nature" the student examines and studies the concept of chance and probability within the randomness phenomena – from a throwing a dice event to observing randomness huge systems. Thus, from the uncertainty that exists in a single event, a general model for randomness in nature is built based on a constructivistic approach (Bedner K., Cunningham D., Duffy T., Perry D., 1992) and assisted with a unique computerized studying environment.

Following a pilot study, the main study was conducted during the academic year 2000. The research population consisted of 150 10th grade students, boys and girls in one high school in the center of Israel. These students belong to humaneistic, scientific, interdiscipline and information technology trends. The experimental group consisted of 70 students who studied the module; the control group consisted of 80 students who studied science according to the established curriculum. Based on the findings, in the analysis of the research the entire population (both experimental and control) was divided into two: The "humanistic" division and the "other" one (which consisted of the scientific, interdiscipline and information technology trends). Both experimental and control groups were assessed before and after the intervention period.

The assessments of the results incorporated both quantitative and qualitative methods:

- A series of tests examining the studies and understanding randomness in nature.
- A validate and reliable attitude questionnaire which factor analysis split it into totally two different questionnaires.
- A unique intuition questionnaire which deals with science, technology, and randomness.
- A questionnaire which checks the relation of the students to a computerized studying environment.
- Ethnographic interviews for triangulation with the research products.

Research hypotheses, to be approved or disapproved were:

1. Solving events in randomness improves scientific intuitive thinking in experiment group comparing to control group.
2. Solving events in randomness improves scientific intuitive thinking in scientific oriented students rather more than in non-scientific oriented students.
3. Studying the module improves attitudes of students in experiment group compared with the control group as for the contribution of science to society.
4. There is no connection between the gender of the student and his scientific intuitive thinking.
5. Studying through a simulation in the computer should be preferred when compared to a frontal teaching together with a real laboratory.

The first two hypotheses, dealing with intuitive ability were approved.

The hypothesis that deals with attitudes towards science (3) was disapproved; however, as for humanistic students, the linkage between personal attitudes towards science and achievements was broken. This is in contrast to the other students where a correlation was found between success (or failure) and their attitudes towards the contribution of science to themselves.

The hypothesis that there is no connection between the gender of the student and his scientific intuitive thinking (4) was approved as well.

The hypothesis that studying through a simulation in the computer will be preferred on a frontal teaching together with a real laboratory (5) was approved. Nevertheless, it came out that not only it was intermediate for learning but as a factor that increases the affinity between the humanistic student and science.

In summary, the education system has to deal with the concept of randomness, as the only and the unique scientific explanation for our wonderful and organized world. Agreeing with Perkins (Perkins, D., 1992) the education system has to lead young students to be familiar to that unbelievable logic structure of the world they face.

For more details visit our web site: *http://ory.ph.biu.ac.il/2000*

You can also contact us at: *cilla@zahav.net.il*

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Studying the Water Cycle in an Environmental Context: The "Blue Planet" Program

Orit Ben-zvi-assaraf and Nir Orion,
Weizmann Institute fo Science, Rehovot, Israel,
Nir.orion@weizmann.ac.il

INTRODUCTION

The end of the 20th century and the beginning of the 21th century can be defined as an era of revolution in science education all over the world. The main goal moves from educating and preparing the future scientists of the society towards the educating and preparing of the future citizens of the society (including the future scientists). This new paradigm is known by the name "Science for all" approach.

Bybee (1993), had pointed on our moral duty to prepare our students toward life in a planet in crisis. In order to acheive this goal the environmental education should be localized in the center of the school curriculum but not in its margins as it occures today. This demand is in accordance with the present goals of science teaching. Orion (1998) noted that education of earth systems should take a central place in the science curricula since the acknowledgement of the critical necessity of environmental literate citizens for our society. The educational potential of this subject is a result of its relevancy to students' daily life and its multi–disciplinary nature. The main purpose of environmental education should be the development of environmental insight. Such insight is based on understanding the systemic and cyclical mechanisms of our planet. Orion (1997) determined environmental insight in two dimensions:

A. The understanding that we are living in a cycled and recycled world which is composed of numerous sub–systems (geosphere, hydrosphere, biosphere and atmosphere), that are connected in tight interrelationship of material and energy transfer, and

B. The understanding that man is an integral part of the natural system. In order to develop such insight one should focus on teaching of geochemical and biogeochemical cycles, such as the water cycle. The study of such cycles should not be sterilized and should be conducted in the context of its influence on man's daily life.

Orion (1998), suggested that systems–thinking in the earth systems context, is fundamental to environmental literacy. He claims that understanding the reciprocal relationships within, and between each of these systems, will enable students to become thoughtful decision–makers, concerning environmental issues in the future.

In order to fulfill the above goals, the water cycle was chosen as the leading concept of the curriculum. The water cycle is a complex system and in order to meaningfully understand it, students must understand the following relationships between the Earth's spheres: (a) hydrosphere and geosphere (e.g. chemical weathering by dissolution, precipitation of minerals from seawater); (b) hydrosphere and atmosphere (e.g. evaporation and condensation); (c) hydrosphere, biosphere and atmosphere (e.g. transpiration). Such understanding, which can be described as "understanding the Earth as a system", may serve as a basis for developing environmental literacy (Kali, Orion, & Eylon, 2000b). Environmental problems are presented within the context of the relationships between the hydrosphere and the other components of the earth's systems. These relationships should also be presented as a matter transformation (especially water) between the different systems.

Despite of the crucial importance of water, it is surprizing to observe that relatively little research has been published concerning the teaching and learning aspects of this topic. Moreover, most of the studies that have been conducted in this area had concentrated on students' perceptions of the physical aspects the water cycle namely, changes in the water state (Bar, 1989; Bar & Travis, 1991; Johnson, 1998a, 1998b).

Brody (1993), had reviewed 51 studies on childrens concept regarding water reservoirs, water characteristics and water cycle. He concluded that a large portion of middle school and high school students, have difficulties in understanding different subjects that are connected to water. For example:

a. Understanding chemical and physical processes such as condensation, evaporization and the molecular structure of the water.

b. The significance of water for processes that take place in living organisms.

c. Understanding of interdisciplinary subjects such as water resources and the social and scientific linkages of these topics.

d Making decisions concerning environmental interdisciplinary subjects such as water contamination, the usage of water as a resource and the preservation of the ecological systems such as the marine environment.

A similar picture was found by Fetherstonhaugh and Bezzi (1992), who reported that after 11 years in school, students present a poor and insufficient scientific conception of the water cycle.

It is worthwhile to note that we did not find any study that focused on children's perception of underground water and their availability.

The design of the "The Blue Planet" program, was based on two main factors: a) epistemological approach for curriculum development, and b) a helical model of predevelopment study, curriculum development, implementation, evaluation and modification.

THE PREDEVELOPMENT STUDY:

The predevelopment study includes the following objectives:

1. To identify junior high school students' previous knowledge and understanding in relation to environmental issues concerning the relationship between human and the water cycle.
2. To identify junior high school students' previous alternative frameworks in relation to the water cycle.
3. To explore students' perceptions of the cyclic and systemic nature of the water cycle.

The sample of the predevelopment study included about 1,000 junior high school students (7th–9th grades) from 30 classes from 6 urban schools.

The data collection was based on a series of quantitative and qualitative research tools that were specifically developed for this study. The following is a brief description of these research tools:

- A questionnaire for Assessing Students' Knowledge (ASK): This questionnaire includes three parts: Part 1 includes a Likert–type questionnaire, where students were asked to mark their level of agreement with a list of statements concerning the water cycle (Table 2). In Part 2, the students were asked to draw the water cycle. For this task, they were provided with a list of the main stages and processes that are included in the water cycle and they were instructed to incorporate as many of these items within their drawings. In part 3 the students were asked to mark in association diagram concepts which they familiar with regarding the water cycle.
- A Cyclic Thinking Questionnaire (CTQ): In this Likert type questionnaire students were asked to mark their level of agreement with a list of statements concerning the cyclic nature of the hydrosphere and the conservation of matter within the earth systems (Table 3). The validation process of the Likert type questionnaires was conducted through the method presented by Orion, Hofstein, Tamir and Giddings (1997) and included the following components: Conceptualization, Internal validation, Construct validity and Sensitivity.
- A global magnitude Questionnaire (GMQ): In order to evaluate the students conception regarding the quantity of each component of the water cycle, they have been asked to fractionate the global quantity of water amongst the water cycle components (oceans, glaciers, rock, soil, ground water, lakes, precipitation, tap water, sewage water, human) in a scale. This scale varies between 1 to 10, whereas 1 is the major component of water content on earth and 10 reflects the minor portion of water on earth.
- Interviews: The interviews were conducted with 40 students, once they had completed the questionnaires. Interviews had two main objectives. They served as a tool for validating the students' answers on the questionnaires; moreover, They provided greater insight into students' perceptions of the water cycle. During the interviews, each student was requested to read his answer, and to say whether he still agreed with his drawing and then to elaborate on his answer.

Results:

Analysis of the predevelopment questionnaires indicated the following findings:

ACQUAINTANCE WITH THE WATER CYCLE COMPONENTS.

Analysis of 956 drawings indicates that most of the students possessed an incomplete picture of the water cycle, which results in many misconceptions. Students that drew the water cycle usually represented the upper half (i.e. evaporation, condensation and rainfall) and ignored the ground water system (Figure 1).

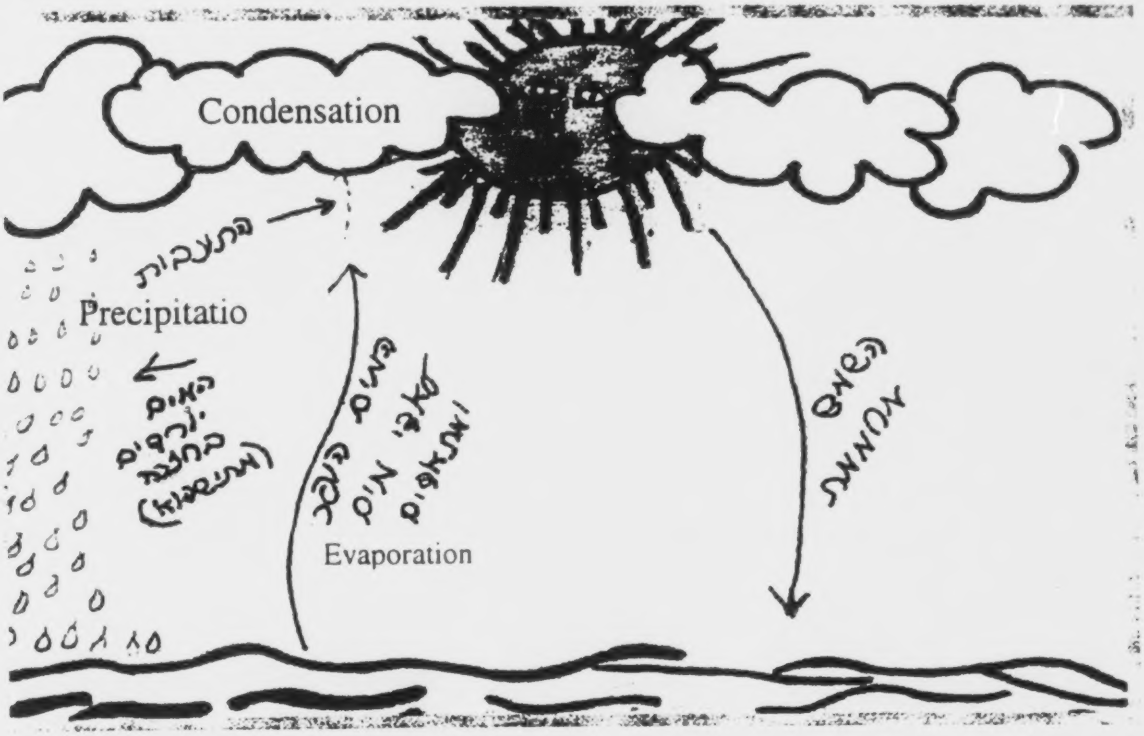

Figure 1: A drawing, which reflects a naive perception of the water cycle.

More than 50% of the students did not identify components of the ground water system even when they were familiar with the associated terminology. Similarly, the most common concepts that students marked in the association diagram were rain, cloud and evaporation that take place in the atmosphere. Less than a third of the students have marked concepts that are connected to the geosphere, biosphere or even concepts concerning to human activities and environmental aspects of the water cycle, within their association diagrams (Table 1).

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Table 1 : Students preceptions as showed in a association diagram concepts, in which students were asked to mark the concepts they familiar with regarding the water cycle.

Cycle components	Examples for terms	Percentage of representative determinations among the group
Atmosphere	Rain, moisture, precipitation, cloud, snow, hale, water evaporations, sky	94.15
Hydrosphere	Fall, waves, puddle, underground water, ocean, river, streams, icebergs	88.9
Processes	Evaporation, condensation, precipitation, water flow, defreeze, flood	65.7
Rock association	Lime, mountains, soil, rocks, cracks, mineral water	27.4
Human activities	Boiling, drinking water, cooking, agriculture, shower, kettle, tap	37.9
Change of state	Gas, liquids, change of atate, temperature, solid, cold, heat	22.5
Biosphere	Food, life, thirst, human being, organisms, plants, tears, nature	19.1
Earth	Recurrence, earth, winter, summer, wind, climate, weather	23.0
Environment association	Contamination, purification, sewage water, bacteria, acid rain, economizing	22.5

UNDERSTANDING THE DYNAMIC NATURE OF THE WATER CYCLE

Understanding processes such as penetration and underground flow is highly important for the development of environmental insight. This kind of understanding may provide students with a tool to explain phenomena such as the influence of garbage dumps on the water quality, for example, in Israel, many dumps are located above sandstone.

Compliation of the data that was collected through the various research tools indicated that most of the students showed difficulties in understanding the dynamic nature of the water cycle. They perceived the underground water as a static, sub–surface lake. Consequently, they perceived underground water as a disconnected system, wherein the water has no relationship with the surrounding rock. Only a third of the students held a vertical dynamic model of the water movement, whereas most of them described this movement in underground rivers both in there drawings and interviews (Figure 2).

"S: Underground water does not stay still, it always flows somewhere. ...I think it flows to the sea. Maybe there are kinds of openings in the earth where the water flows from the earth to the sea"

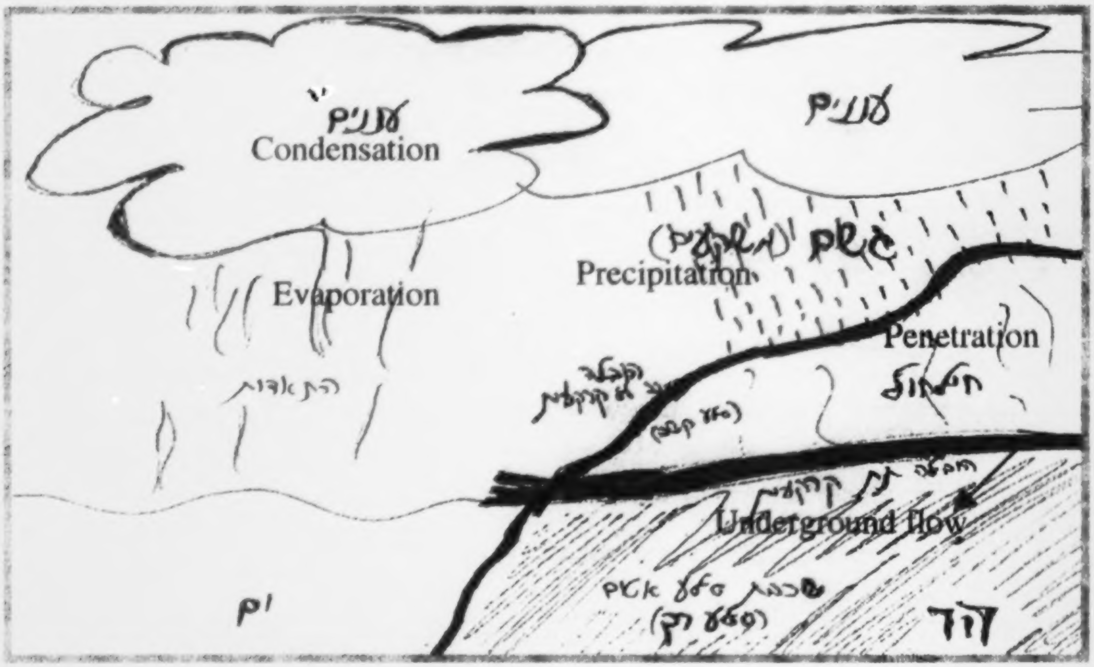

Figure 2: A drawing, which describes the underground water as underground river.

It was found that most of the students were not aware of the underground movement of water in earth. Amongst those who were aware of underground movement only 23% thought that rain which penetrate through rocks, may move horizantally under the ground to the sea and only 20% held a scientific model of underground water movement through porous rocks. Therefore, most of the students claimed that underground water can be found only in rainy areas (Table 2).

STUDENTS CONCEPTIONS OF THE WATER DISTRIBUTION ON EARTH

Most of the students possessed an incomplete picture of the water distribution on earth. For example, 78% claimed that the amount of available water in rocks is small and even smaller than the amount of water existing in rivers or lakes.

About 80% of the students did not connect between the relative size of the oceans and the amount of precipitation that fall on oceans. They claim that most of the global precipitations fall on land, eventhough 70% of the earth surface is made of oceans. As a results there drawings show that water evaporates only from the ocean and rain falls only on land (Figure 3).

Most of the students have magnified the human part in the water cycle. For example, many students drew the water cycle with the emphasis on human consumption (e.g. pipe and tap water, etc.). 45% of the students ranked the partial amount of tap water, sewage water and water in human's bodys, high above their realistic values.

Table 2: Students preceptions as showed in a Likert–type questionnaire for Assessing Students' Knowledge (ASK).

Statements	Agreement	Uncertainty	Disagreement
1. The composition of a cloud, which has formed above the "Sea of Galilee" is different than a cloud that has formed above the "Dead Sea"	28	24.3	47.7
2. Most of the rain falls on the ocean and only small portion falls on lend.	18.2	24	57.8
3. Most of the underground water persist in the small porouses in the rock, similarly to a well-watered sponge	25.7	43.4	31
4. Under ground water is similar to underground lakes that are located in spaces in side the soil	49.5	26.6	23.9
5. Only when rocks are cracked can water penetrate them	28.8	23.1	48.2
6. The water that is leaching into the rocks flow to the sea under the surface	23	43.7	33.2
7. Most of the rain that falls on the ground is penetrating into the rocks and only small portion flow in streems and rivers.	24.8	27	48.2
8. Rocks don't influence the composition of water that leachate through them, since the hard rocks don't break down in water	46.9	29.7	23.5

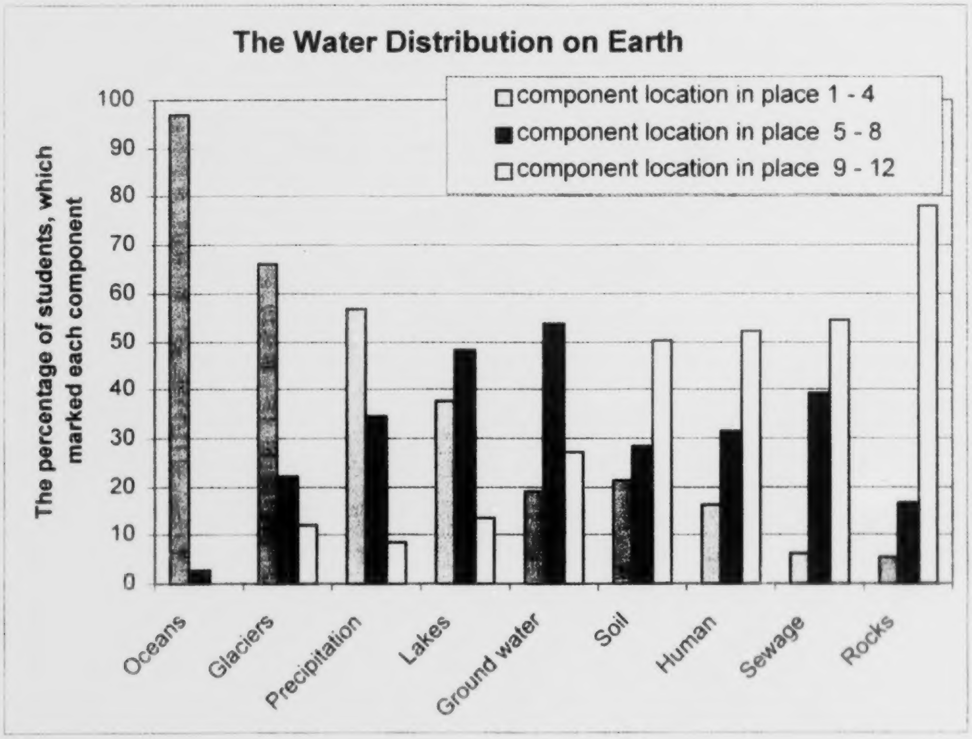

Figure 3: Students perceptions as showed in – A global magnitude Questionnaire (GMQ), In order to evaluate the students' conception regarding the water distribution on earth

UNDERSTANDING OF PHYSICAL AND CHEMICAL PROCESSES OF THE WATER CYCLE.

Understanding of processes such evaporation, condensation and dissolution is critical for the understanding of matter transportation within and between the earth subsystems.

Analysis of the questionnaire and interviews show that most of the students could explain evaporation process according to the particles model (as they studied in class).

However, they had difficulty in connecting this "physical" process with the natural phenomenon of evaporation within the water cycle. Students that in the interview could clearly explain the "particle model" could not use this model to explain water evaporation in nature. Since in most of the science lessons teachers tend to present evaporation in context of boiling water, students tend to claim that evaporation can only occur in hot water. As a result some students drew kettle in their water cycle drawings. 47.7% of the students did not agree with the statement that: *"The composition of a cloud, which has formed above the "Sea of Galilee"* is different than a cloud that has formed above the "Dead Sea". Analysis of the data implies that students perceive, the chemistry of the water solution as constant throughout the entire water cycle (Table 2).

UNDERSTANDING THE CYCLIC NATURE OF THE WATER CYCLE.

Cyclic thinking is the ability to perceive matter transformation within and among the earth systems, as a part of cyclic process. A process in which the overall amount of matter is being preserved. Cyclic perception includes the understanding that there is no start or end points within the cycle.

The analysis of the data indicates that more than 50% of the students claimed that the water cycle has a starting and end points (Table 3). " *There must be a starting point; the end point I don't know. The end point could be either the sea or groundwater...*"

A similar amount of students also agreed that *"the amount of water in the ocean is growing from day to day because rivers are continuously flowing into the ocean"*.

A positive correlation was also found between those students who included groundwater in their drawings and those who demonstrated cyclic thinking in their questionnaires.

Table 3: Students preceptions as showed in a A Cyclic Thinking Questionnaire (CTQ). A Likert–type questionnaire for assessing student's understanding the cyclic nature of the hydrosphere.

Statements	Agreement	Uncertainty	Disagreement
Ocean is the starting point of the water cycle and ground water is its end point.	17.7	27.7	54.6
The amount of water in the ocean is growing from day to day because rivers are continually flowing into the ocean".	26.3	29.6	44.2
The increase in waste that human produce causes to incease in earth mass (weight).	22.5	26.9	50.6
Massive mining (quarrying) of minerals causes to earth mass (weight) decrease.	10.9	34.5	54.5

UNDERSTANDING OF THE SYSTEMIC NATURE OF THE WATER CYCLE.

Systemic thinking is the ability to perceive the water cycle in the context of its interrelationship with the other earth systems.

Analysis of the data indicates that students tend to diminish the influence of the geosphere on the other water cycle components. 48% of the students do not identify a connection between springs and the water cycle and 34% cannot identify such relationships with the rocks. Only 20% of the students understood the connection between the composition of the water solution and the rock which they pass through, *"Rocks don't influence the composition of water that penetrate them"*.

The interviews revealed that students perceive the interaction between the rock and the groundwater as a physical or mechanical processes.

Q – " How does water influence the rocks?"

S – " The water can make or expand cracks in the rocks".

Q – " Is there any possibility that rocks can influence the ground water?

S – "I do not think so!"

SUMMARY OF THE RESULTS

The followings are the main findings of the predevelopment study:

1. Most of the students possessed an incomplete picture of the water cycle.
2. Most of the students perceive the underground water as a static body.
4. The students showed difficulties to identify relationships amongst the various components of the water cycle.

5. Most of the students have difficulties to perceive interrelationships between the water cycle and other earth systems, mainly the geosphere.
6 The students showed difficulties to transfer basic knowledge in physics and chemistry in order to explain relavant processes that occur within the water cycle.
7. Most of the students have difficulties in perceiving matter transformation within and between the earth systems, as a part of cyclic process in which the overall amount of material is preserved.

DISCUSSION:

The main goal of the Blue Planet program is the development of environmental insight, in order to provide students with skills so they can translate environmental problems, such as water pollution, into a more coherent understanding of the environment. Yet, it appears that while entering junior high school, most of the students possess a partial and fragmental understanding of the water cycle, as well as many alternative frameworks. Moreover, most of the students have difficulties in understanding the systemic and cyclic mechanisms of the water cycle and its relationship with mankind.

As previously mentioned, earlier studies had already indicated that junior and high school students hold many alternative frameworks concerning the water cycle (Bar, 1989; Bar & Travis, 1991; Brody ,1993; Fetherstonhaugh and Bezzi,1992). Thus, the development of any curriculum in this area should emphasize the including of learning strategies to enhance conceptual changes. Today, while science education is deeply related to the constructivist approach, there are dozens of articles and books that deal with student–oriented education and strategies such as the cognitive conflict that might create a personal conceptual change (e.g., Brody, 1994; Strike and Posner, 1985; Trowbridge and Bybee, 1996).

Our findings indicate that students do not relate their school learning of the water cycle to their daily experience. This finding is quite surprising since there is no doubt that the water cycle is mostly relevant to our daily life, espacially in a semi arid area. It is suggested that this finding indicates that dealing with a relevant subject is probably not enough for making it relevant in the students' eyes. In order to do so the whole learning process should be conducted in a way that the students will see the relevancy of the learning from the first step throughout the whole curriculum. Thus, it is suggested that instead of dealing with the water cycle in light of its physical and chemical processes, it should be learnt in it environmental–social context. It is important to note that we do not suggest to omit the physical and chemical processes out of the curriculum, but only to change the order of learning. First to create the relevancy and interest among the students and later to teach the more abstract part of the scientific curiculum while it was needed to solve a specific authentic problem. This strategy is very similar, of course, to the well documented approach known as STS (e.g., Bybee, 1987, 1993; Hofstein et al., 1988; Orion, 1998).

Our findings underline the ignorance that exists among students concerning the role of the geosphere in the water cycle. In the "Science for all" era, while the main purpose of science education is defined as the education of our future citizens, such lack of knowledge cannot be accepted by any society. This strong statement was written since most of the environmental topics such as river pollution, quality of drinking water, and contamination of ground water, are commonly derived, at least in part, from society's ignorance of the role of the geosphere within the earth systems. Thus, any curriculum that deals with the water cycle should emphasize the learning of processes that occur in the geospheric system such as the interrelationships between the type of rocks and the existence of underground water and the interrelationships between the type of rocks and the water quality. However, the high frequency of alternative frameworks found by this study and their broad appearance is not only the result of inappropriate teaching, but also a reflection of the complexity of the hydrology concepts mentioned above. This complexity is derived from the level of abstraction that is needed for understanding hidden processes that take place under the ground. Thus, a curriculum that involves the water cycle should emphasize activities to concretize the hidden underground part of the cycle. One way of concretization of the underground system is the use of 3D models, where students can confront their alternative conception through instructed and constructed activities and self–investigations. While working with such models, students could gain the opportunity to translate environmental phenomena to the higher level of relationships amongst components of the water cycle. However, models and simulations can give only a partial solution to the concretization of abstract processes. Moreover, they always lead some students to develop new misconceptions about the natural phenomena that they try to demonstrate. Thus, there is no ideal substitute for the real world than the real world itself. Therefore, any curriculum that deals with natural phenomena should use the outdoor learning environment as much as possible. Orion & Hofstein (1994) have suggested that the main role of the outdoor learning environment within the learning process is a direct experience with concrete phenomena and materials. It is suggested that Orion's (1993) model for conducting an outdoor learning as an integral part of the whole learning process can serve as a useful tool for emphasizing the role of the geosphere in the water cycle. This model may help the students to connect and integrate learning materials, such as knowledge that was acquired in the lab and classroom with components of the earth systems as they appear in nature. Moreover, questions that may be raised in the authentic situation as the result of the encounter and interaction with the real world might serve as a powerful motivator tool to delve into the learning of abstract concepts and complex interrelationship later in the classroom. Even if some students are familiar with some of the water cycle components in nature, they still face some difficulty in the perception of the global systems. The direct encounter with locations and processes might enable student to create a concrete local water cycle, which might later enlarged into the more abstract, global cycle.

In contrast to the poor acquaintance of students with the geosphere components of the water cycle, most of the 8th and 9th grades students stated that evaporation is one a familiar and understandable process that was learn in 7th grade. Nevertheless, similarly to studies of Bar (1989) and Bar & Travis (1991) this study indicates that most of those students express difficulties in understanding the process of evaporation in the natural context and tend to claim that evaporation can occur in hot water only. Johnson (1998a) and Johnson (1998b) suggested that the basis for understanding the water change of state by students should be the understanding of the "particle model" which emphasized the particle nature of substance. All the students in this study had spent a lot of time and efforts to study the "particle model" of matter, but yet most of them could not use it to explain water evaporation. Our findings suggest that even those students did understand the particles model of matter, they still had difficulty to transfer it in order to explain a real world situation. Consequently, the claim that the first subject in the junior high school science learning should be the particles model, since this is the ultimate gate to understand science does not fit to the "Science for all" era. Alternitivaley, it is suggested that studying the particles model in the context of learning of natural phenomena, in a context of authentic and relevant situation might be more useful for most of the students. Thus, the studying of the water cycle could serve as a poerful platform studying the particles model, rather than being taught as a separate or disconnected physical and chemical processes.

Our findings concerning students' difficulties in perceiving the hydrosphere as a coherent system may suggest that this cognitive ability depends on both scientific knowledge and high order thinking skills. It is suggested that the perception of the water cycle as coherent system involves the operation of two high order thinking skills, namely cyclic thinking and systemic thinking.

Our analysis suggests that students perceive the "water–cycle" as a set of unrelated pieces of knowledge. They understand various hydro–bio–geological processes, but lack the dynamic, cyclic and systemic perceptions of the system. One of the methods for dealing with students' tendency to compartmentalize knowledge is the use of knowledge integration activities (Linn, 2000; Kali, Orion & Eylon, 2000b). Kali et al (2000b), reported a meaningful improvement of students towards the higher part of the systems–thinking continuum concerning their perceptions of the rock–cycle. This improvement was a result of knowledge integration activities. Such activities included a type of concept network drawing, in which the component of the rock cycle was represented. After studying each process (inquiry activities), students were requested to add arrows to represent the process that they have just learnt. Finally, students` work represented the dynamics of material transformation in the rock cycle. It is suggested that similar knowledge–integration activities could be also use for the construction of the water cycle as a dynamic cyclic system.

Implications

Following the findings and the discusion presented above it was decided that the new curriculum "The blue planet" that have been developed for 8th grade science students will include the following components:

1. Using constructivistic methods to alter the students misconceptions of the water cycle.
2. Presenting a coherent depiction of the various processes at each stage of the water cycle.
3 Presenting a systemic approach of environmental problems, namely relating the water cycle to the various parts of the earth system.
5. Focus on skills, rather than on content.
6 In order to allow the students to acquire Systemic thinking, summary activities such as concept map were designed.
7. Adapting an holistic learning environments approach including the outdoor learning environemt as an integral part of the program.
8. Presenting the water cycle in a Science Technology and Society (STS) format.
9. Using computers to access global data bases so that the students will better understand that the water cycle is a worldwide phenomenon.
10. Presenting the multi–disciplinary nature of science.

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Primary School Pupils' Awareness of Environmental Issues: The Influences of Teaching Styles and Activities

Chrysanthi Kadji-Beltran, *edrda@yahoo.com*
Susan Barker, *s.barker@warwick.ac.uk*
George Raper, *G.Raper@warwick.ac.uk*
University of Warwick, UK

INTRODUCTION

Learning to care for the environment is important for the quality of life and future prosperity. For Cyprus, Environmental Education is part of the "Action Plan for the protection of the Environment" set by the Ministry of Agriculture, Natural Resources and Environment, as an important requirement of the general harmonisation and adjustment of the Cyprus legislation to the corresponding legislation of the European Union. The statement indicates that:

> *"Environmental Education should be introduced through every curriculum topic in Cyprus Education, with special emphasis on the Primary and Secondary level of Education" (Ministry of Agriculture, Natural Resources and Environment, 1996)*

Environmental Education programmes exist both in formal and non – formal education with some initiatives already in place in Cypriot schools as a response to the constantly growing demand. However, there is still the need for development and inclusion of an Environmental Education policy in the formal curriculum since its introduction has solely been mentioned in official documentation by the ministry of Agriculture, National Resources and Environment.

In order to convince decision makers of the importance and value of environmental education Bennett (1987) has suggested that:

> *"if we want to convince the educational community that environmental education can improve the curriculum and make it more relevant to students, we must evaluate our programmes (p.14)"*

Such evaluation would not only show the contribution of environmental education for a more meaningful and enriched curriculum, but may also highlight its effectiveness on inculcating environmental awareness and cognition, through examples of good environmental education practice. It would also provide foundations on which to base an environmental education policy.

Fien J. (1999) et al., gives two reasons for a whole school approach to an environmental policy: The first is that every teacher is responsible for infusing environmental education into his/her teaching in order to help students to live and work towards a more sustainable environment for all. The importance of integrating environmental education in all curriculum subjects is also highlighted by the Tbilisi declaration (1978):

> *"environmental education is not to be added to educational programmes as a separate discipline, or programme of study but as a dimension to be integrated into them. Environmental education is a result of reorientation and re-articulation of the various disciplines and various educational experiences (natural sciences, social sciences, arts and letters etc.) providing an integrated perception of the environment".*

Classroom environment and activities out in the open provide useful information and skill acquisition to the students. This will be of no use if the students do not make sense, internalise the acquired knowledge and realise its practical application in real life situations. What children learn in school has to be mirrored in real life. They will not learn to live by the "rules"[1] inculcated by the school if they do not see their teachers and adults in general living by the same rules:

> *"Young people cannot be expected to value the environment if it is obvious to them that it is not valued by the school. It is therefore important that schools should practice what they teach about the environment..." (CEE 1995, Develop an Environmental Policy; A Call for Action for Schools, RSPB)*

This is precisely the second reason for a whole school environmental policy. Fien et al (1999) suggest that a whole school approach "relates to things students learn from non formal aspects of their experiences in school. *It is important that schools operate as a sustainable environment in their consumption and use of resources and management of waste products. In this way they can reinforce the knowledge, values and action objectives of environmental education being taught as part of the formal curriculum".* (p.2, module 2)

There is a growing mandate for such an environmental policy. Countries, signatory to Agenda 21 have produced national plans for sustainable development (local agenda 21) and they require means of supporting these plans. Environmental quality is a common concern and educational systems can respond to this social demand by introducing whole school environmental policies.

The Foundation for Environmental Education in Europe (FEEE) Eco School programme aims to raise students' awareness of Environmental and Sustainable Development issues through classroom study. It provides an integrated system for environmental management of schools using priority issues, such as water, waste and energy during the first years of the programme's implementation. Schools that have completed the suggested topics have the flexibility to move on to different areas such as transport, health, nature and biodiversity. A key objective is to reduce schools' impacts on the environment by encouraging children themselves to take action. The programme extends learning beyond the classroom and develops responsible attitudes and commitment both at home and in the wider community (FEEE, 1999). Schools with high achievement in the programme receive the Eco Schools green flag, an award recognized and respected as an eco–label for environmental education performance.

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[1] Not in the sense of obeying commands, but rules they set for themselves out of respect for others and for nature.

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RESEARCH AIMS:

The purpose of this study is to:

1. Evaluate the impact of the Eco Schools Project in Cyprus, in particular on primary pupils' knowledge and attitudes towards current environmental issues such as water use, waste management and energy consumption.
2. Examine which factors might contribute to the programme's successful implementation
3. nvestigate how the inculcation of environmental attitudes and understanding of environmental issues, can be influenced by the kind of activity.

The research questions emerge from the research aims.

1. Is there any impact of the Eco Schools Project in Cyprus, on primary pupils' knowledge and attitudes towards current environmental issues such as water use, waste management and energy consumption?
2. Do the following factors affect the programme's successful implementation?
   a. Teacher cooperation and participation
   b. Student participation
   c. Local community involvement
   d. Local authority involvement
3. Is the inculcation of environmental attitudes and understanding of environmental issues, influenced by:
   a. Whole school activities
   b. Age group activities
   c. Indoors activities
   d. Outdoor activities

METHODOLOGY:

In order to answer the research questions, data has been obtained through a combination of research tools and approaches:

The first research tool used was a *comparison test* directed to 675 students of the 5th grade in 7 Eco Schools (experimental group) and 7 schools outside the project (control group) Stratification of the sample facilitated the participation of schools from most parts of the island as well as all school types. (urban – rural, small – big) All Eco Schools (at the time the investigation was held) were 24. The control group was intentionally chosen; in order to ensure compatibility among the schools that would be compared (school size, socioeconomic background of the students' families, students achievement, number of teachers …)

The questionnaire included questions that evaluated students' cognition and information level about several environmental issues as well as questions (Lickert type) and statements that could provide the researcher with information about students' environmental attitudes and actual commitment. (Leeming C. M. et al, 1995, p.22)

The results of the test also facilitated a ranking of the participating ecoschools according to their performance. The selection of *three case studies* was based on the school with highest performance, the school with lowest performance and the school where the programme appeared to have maximum impact.

A qualitative case–study approach of each of these schools gives information on the importance and effectiveness of factors such as teacher, teaching styles, classroom activities and whole school activities. The research instrument used for the investigation of the influencing factors was *document analysis* of the reports submitted to the National Operator to assist school evaluation (1999/2000). These were comparable because they follow a format of 12 common questions to be answered about the application of the programme. In some of the cases the comparison revealed differences, which could answer some of the research questions too.

Table 1. Eco Schools Evaluation Report Questions

Report Questions	Research Questions
1. Which people constitute the Eco Committee of the school?	RQ2.1-4
2. How was environmental audit organized?	
3. How were the action plan targets decided?	RQ2
4. In which level have you advanced with the target attainment?	
5. How do you monitor and evaluate progress?	
6. Write the number and ages of the children involved in activities through the curriculum and information on the topics covered	RQ2.2
7. Describe your environmental action day.	
8. How was the community informed about the Ecoschool Programme and how did they respond?	RQ2.3 RQ2.4
9. Describe any conducts your school had with the wider community (aid, publicity, financial support)	RQ2.3 RQ2.4
10. Please include your Eco Code and describe the way it was composed.	RQ2.2 RQ3.1
11. Has the Ecoschool Programme experience helped your school in any way?	RQ2.1
12. Other comments	

Finally, a questionnaire directed to all 7 Eco Schools' teachers also provided information about the kinds of activities most commonly used by the teachers.

Table 2: Outline of Methodology and Research Questions

Research Question	Target group (sample)	Research approach	Research tool	Sampling method	Method of analysis
1	5th grade students	Quantitative experimental	Comparison test - questionnaire	Stratified random sampling for control group	Inductive statistics $P \subseteq 0.05$
2a	Teachers in the three schools	Qualitative Case study and qualitative Case Study	Questionnaire School evaluation reports	All teachers 3 Reports already selected in aim 2	Descriptive statistics Document analysis
2b			School evaluation reports	3 Reports already selected in aim 2	Document analysis
2c			School evaluation reports	3 Reports already selected in aim 2	Document analysis
2d			School evaluation reports	(3 Reports already selected in aim 2)	Document analysis
3a	Case study of 3 Ecoschools	Qualitative Case study	School evaluation reports	Selection of the school with the highest score, the school with the average and the school with the lowest achievement score, according to the ranking that resulted from research aim 1.	Document analysis
3b					
3c					
3d					

RESULTS

Students' questionnaire:

The environmental management of the school and the environmental education offered by the Eco School Programme have resulted in the cultivation of positive attitudes towards the environment by the students. These are significantly higher in the eco–schools than in the control

schools. The graph illustrates the difference on the environmental attitudes score, between the 14 participating schools and also presents the ranking of the participating eco Schools, according to their environmental attitudes achievement in the test.

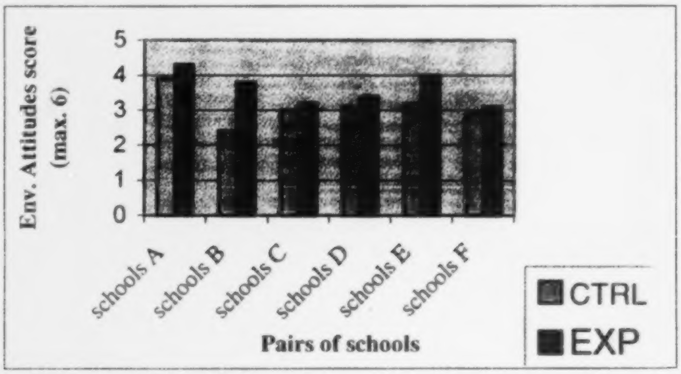

Fig. 1. The programme's impact on students' attitudes.

The comparative study between the school with highest performance (school A), the school with the lowest performance (school C) and the school where the programme had the greatest impact[2] (school B), demonstrated that the differences could be explained by factors such as the teachers' enthusiasm and cooperation, the number and kind of activities used, as well as student involvement in the programme.

Document analysis:

The following pages present only the outcomes of the questions where the results were significantly different. These clearly justify the ranking of the three schools and answer some of the research questions:

QUESTION 1. Which people constitute the Eco Committee of the school? (RQ2)

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[2] Schools F, could not be used because they were small schools, with onlyy a few students. For the case study we opted for common school types that could be comparable.

Table 3: Teaching staff's participation in Eco School Committee.

	School management	Teacher coordinator	teachers	School cleaners	Child care
School A	2	1	6	1	1
School B	3	1	3	1	-
School C	1	1	9	-	-

Table 4: Local Community's participation in Eco School Committee.

	School maintenance committee	Local authorities	Parents association	Highschool links	Energy specialists
School A	2	1	3	1	2
School B	1	3	1	-	2
School C	-	-	-	-	-

Table 5: Students' participation in Eco School Committee.

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Student committee reps	Total
School A	2	2	2	4	4	4	2 (other than previous)	20 (out of 274, entire school)
School B	-	-	-	Not stated	Not stated	Not stated	11	11 (out of 320, entire school)
School C	-	-	-	Not stated	Not stated	Not stated	Not stated	Not stated

School A managed to involve more effectively the entire school community in the environmental committee and especially ensured a balanced participation of children from all ages. They also included specialists to assist them with the topic of the year, which was energy. The same, but in a lower degree were achieved by school B. School C indicates that a greater number of teachers were involved, but they clarify that out of 9 teachers, 6 were initially involved in the programme and eventually, 3 out of 6 opted out before completing their responsibilities. The fact that they also fail to provide the number of students participating in the committee could reveal lack of organisation and commitment.

Information about school and community communication and cooperation were also available in document questions 8 and 9. In all cases, communication with local authorities and community was held through schools' newsletters and members' participation in the committee meetings, (which were not many in full body). The help received by the schools from the community and authorities was either financial (for school improvement and maintenance) or had the form of a visit. The visit could be from the school to a place within the community (e.g. oil refinery or power plants) or a visit from a community member, as specialist on energy issues (topic of the year)

QUESTION 3. How were the targets of the action plan decided? (RQ2)

For all schools the committee decided the final targets, taking under consideration the results from the audit and coordinators' suggestions. Only School A used specialized guests to assist the committee meetings and gave the students the opportunity to put down their suggestions. The whole procedure in school A appears to be more democratic and involves a greater number of children (suggestions box available to everyone).

Table 6: Action plan development process

	Decided by	Based on	Applied by
School A	Entire committee	Students suggestions Specialists presentations Adults suggestions (committee members) Coordinator's ideas Environmental audit Previous years experience	All school
School B	Entire committee	Environmental audit Previous years experience	Classroom distribution
School C	Entire committee	Environmental audit PI seminars (coordinator's experience) Previous years experience	Classroom distribution

QUESTION 4. In which degree did the school achieve the targets?

Schools A and B stated that they have completed almost 100% of their targets and school C 75%. Nevertheless, there is a huge difference in the number of targets set by the three schools. School A set 66 targets, school B 18 and C 20. Compared to the size of the school (number of students and teachers), it should be vice versa. Action Plans and the targets are submitted for approval, at the beginning of the year, to the National Operator.

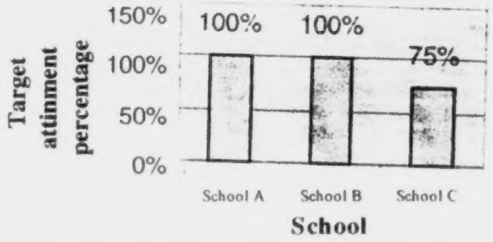

Fig. 2. Target attainment level by the three schools.

The Eco School Award does not imply a competition between schools, but "competition" of each school with itself. Nevertheless, where the differences between the schools are not radical, the differences between the school targets should not be expected to be so. The National Operator should establish target balance among schools. Another important factor for the inculcation of environmental attitudes in school settings, is the school's ability to incorporate the environmental dimension in classroom activities (the school curriculum) and whole school activities. Again the number, and variety of activities applied by school A is much higher than the other two schools.

QUESTION 6. Write the number and ages of the children involved in activities through the curriculum and information on the topics covered. (RQ2.2, Q3)

All schools state that all children participated in the programme. The level of participation, though, varies. While in school A, all children participated in a number of common activities, in other schools the activities were distributed in classes (age groups). In this case, children did not acquire a holistic view of the topic: they only experienced the activity applied by them. This is made explicit by a comment of the teacher coordinator of B Primary school: "... all children actively participated *at a point of the programme*"

In general, the activities performed in all schools were similar. The categories of activities and the number of activities applied in each school are presented in tables 7 and 8. Competitions and patrols for maintaining school grounds clean, saving energy and water were common whole school activities. Some of the schools visited a power plant and an oil refinery station. Guest speakers from environmental organisations visited all schools. Curriculum connections with energy took place in science classes (electric circuits, forms of energy, hazards from electricity and protection measures, etc.) as well as other topics (e.g. food chains, pollution experiments) but not in every school. Nonetheless, the distribution of the activities in the various classes was different. School A distributed all whole school activities to all classes[3] (poetry competition was practically impossible to include the first year due to the limited writing skills of their age) and many curriculum activities were common wherever possible. School B, having a narrower range of ages could apply all curriculum activities in all classes. Nonetheless, not all the activities were directed to all children in the classroom. School C, did not include any activities emerging from the curriculum but they included monitoring activities. Those were distinguished and directed to different classes. Consequently, although the school as a whole could demonstrate a variety of activities, each class had a limited experience of environmental issues. Some of the activities in schools B and C were even applied by groups of children.

The school with highest performance (school A) directed all of its activities to all classes and in this way achieved two things: firstly everyone was involved in all of the activities, and secondly these activities clearly gave children an obvious common purpose and team spirit. School A was more effective in inculcating environmental attitudes to the students, perhaps because they participated in a great variety of activities in the classroom as well as in whole school activities that offered them a lot of experiences. A common objective, for all students promotes team spirit and dedication to the common purpose.

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[3] School A is a school that has united lower and upper primary so children's ages range from 6 to 12, whereas schools B and C include only upper primary (9–12 years old).

The activities performed could be distinguished in four categories: indoor activities and outdoor activities, as well as specific age group directed activities and entire school activities. The following table illustrates the variety of activities performed by all schools and their distribution in the 4 categories.

Table 7: Categories of teaching activities

Vs	In doors	Outdoors
Specific Age Group	• Curriculum oriented indoors classroom activities	• Curriculum oriented outdoors classroom activities • Visits • Monitoring and investigations for materials collections
Whole school	• Poetry competition • Song Composing Competition • Assemblies • Guest speakers Material collection (e.g. aluminium tins for recycling, or clothes for Red Cross donations…)	• Tree planting • Patrols (energy saving patrol, water saving patrol) • Garden, school grounds maintenance

Table 8.1: Numbers and categories of activities applied by each school

	School A		School B		School C	
	Indoors	Outdoors	Indoors	Outdoors	Indoors	Outdoors
Specific age group	33 (average 6 activities per class)	4	8 (the same 8 in all classes)	3	4	1
Whole school	12	5	4	4	2	1
Total	54		35		8	

Table 8.2: Numbers and categories of activities applied by each school

Activities	Classroom activities	Whole school activities	Guest speakers	Visits	Total
School A	34	14	3	3	54
School B	24	8	2	1	35
School C	4	4	-	-	8

Teacher questionnaire

Question B2, in the teachers' questionnaire aimed to confirm the variety of activities stated in the evaluation document.

In which degree do you apply the following activities?

(1: none, 2: very little, 3: enough 4: quite a lot, 5: a lot)

Table 9: Activity's application levels

Participation of the class in the annual assembly for the environment	3.57
Tree planting	3.4
Make use of environmental content mathematics problems	2.5
Organise special visits (e.g. forestry department, dams, desalination units, waste disposal units etc.)	2.8
Field study	2.4
Participation in the annual beach cleaning activities	2.57
Make use of "rubbish", for artistic creations	3.51
Essays and assignments about Environment	3.41
Discuss over Environmental Problems (e.g. greenhouse effect, acid rain, pollution etc.)	3.6
Recycling	4.0
Try to minimise waste produced in the class	3.67
Out door study	2.6

CONCLUSIONS

The composition of the environmental committee is important. The participation of the school staff and their cooperation is essential for the successful application of the programme. The work distribution among the teaching staff, makes a programme no one's burden. Support for the programme, also comes through the participation of many members of the local community in many ways. Their active involvement benefits both the school and the society. This general participation along with the participation of a high percentage of the schools students promotes cooperation and strengthens school – community relations as well as teacher – students relations. The global participation into decision making and application also results to a democratic operation of the school functions and enhances the schools team spirit. The equal representation of each class in the Environmental Committee promotes a democratic climate in schools' organizational and administrative procedures. It also facilitates the active participation of the students and promotes their initiative. (Classroom representatives carry class' messages to the committee)

Beyond the operational level, in the cases where the activities for the implementation of the action plan targets involved all school, children were affected by the programme in a higher degree and developed environmentally friendly attitudes. This is probably due to the team spirit created, and the commitment the children felt. Activities such as guest speakers, or days devoted on environmental issues, offer opportunities for further involvement and information of the children. The kinds of activities described above are out of classroom and community based activities. According to Knapp (1983), these are the precise activities that support action learning, an approach to environmental values education. This approach "provides opportunities to individuals and groups to act on personal values in the context of real issues and problems" (p.24).

The number of objectives often reflects the number of activities performed by each school. As observed in question 4, the more activities performed by the children, the greater is the impact of the programme on the children.

One of the most important factors for the effective application of a programme is the people's feelings about it. Question 11 reveals the feelings that school A holds about the programme: they feel proud of their participation, something that was not stated by any other school. This feeling, essential for the successful implementation, is probably a result of the team spirit emerging from the common whole school activities.

These conclusions cannot be generalized, because of the limited number of schools used for the comparison. They clearly emerge from the case study of the three schools. The results presented above will be investigated further, through interviews with the teacher coordinators and the school director.

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A Virtual Journey within the Rock-Cycle: A Software Kit for the Development of Systems-Thinking in the Context of the Earth's Crust

Yael Kali, Carmel Gorni and Nir Orion,
Weizmann Institute of Science, Israel
nir.orion@weizmann.ac.il

INTRODUCTION

Developments in the last few years of earth science education can be characterized by a shift towards a systems approach to teaching and curriculum development. This shift can be illustrated by the main theme of a conference, held in Hawaii, "Learning about the earth as a system" (Fortner, & Mayer, 1998). This theme was chosen "because it emphasizes the importance of reexamining the teaching and learning of traditional earth Science in the context of the many environmental and social issues facing the planet… it is imperative that students at all grade levels and from all cultures have an understanding of how the earth works" (p.3). Orion (1998), claims that systems–thinking of the different earth systems, i.e., the geosphere, the hydrosphere, the atmosphere and the biosphere (including mankind), is a fundamental step in order for students to reach environmental literacy. He claims that understanding the reciprocal relationships within, and between each of these systems, will enable students to become thoughtful decision–makers, concerning environmental issues in the future.

The type of thinking needed for understanding systems, have been extensively studied in many domains including the social sciences, (e.g., Senge, 1998), medicine (e.g., Faughnan, & Elson, 1998) psychology (e.g., Emery, 1992), curriculum development (e.g., Dror, 1984), decision making (e.g., Graczyk, 1993), project managing (e.g., Lewis, 1998) and engineering (e.g., Fordyce, 1988). According to O'connor, & McDermott (1997), a system is an entity that maintains its existence and functions as a whole through the interaction of its parts. Systems–thinking according to them, "looks at the whole, and the parts and the connections between the parts…" Frank (1999) regards such thinking, as a higher order thinking skill, which is a highly important way of thinking, in many domains. The significance of systemic thinking was emphasized by Senge (1998), who claimed that in a world of information explosion, in which systems are becoming more and more complex, systems–thinking is a fundamental skill.

In a study characterizing the specific systems–thinking required for understanding the rock–cycle (Kali, Orion, & Eylon, 2000) we defined the three elements of general systems–thinking as being: a) understanding of the parts of a system, b) understanding the connections between these parts, and c) understanding the system as a whole. Accordingly, we suggested that in the rock–cycle, the first element (i.e., the parts) involves acquaintance with different materials comprising the crust of the earth, which are mostly different types of rocks in solid or liquid state, as well as the geological processes producing them. The second element (i.e., relationships) involves understanding causal relationships between specific processes and their input and output products. The third element (i.e., the holistic aspect) involves understanding that each output product from one process can serve as an input product to another process, so that the materials of the crust are recycled through endless cyclic chains of processes and products.

In the same study (Kali, Orion, & Eylon, 2000), it was found that an understanding of the dynamic and cyclic nature of the rock-cycle was not reached by most students at junior high school level, even when they understood all the relevant geological processes and their products. However, a summative knowledge integration activity brought about a meaningful improvement in students' views of the rock-cycle. Following this activity, students became more aware of the dynamic and cyclic nature of the rock-cycle. Moreover, their ability to apply this awareness and construct sequences of processes, representing material significantly improved (Kali, Orion, & Eylon, 2000).

As a result of this study we decided to develop additional aids for assisting students to integrate their knowledge of the rock-cycle to further enhance the students' perception of the rock-cycle. We searched for a type of activity that would make the dynamic and cyclic nature of the earth's crust more concrete. One such activity could be for students to follow a journey, such as the one described by Jules Verne in his "Journey to The Center of the Earth", and "participate" in activities such as riding a lava flow. This would certainly "bring alive" the idea of material transformation within the rock-cycle. Although such an educational field trip is, regretfully, beyond the scope of our capabilities, a virtual journey was chosen as a satisfactory alternative and the computer was chosen as the tool for the activity.

The computer is a tool well-suited for enabling students to experience such a journey. An important advantage of the computer is that it enables the construction of microworlds (Elshout, & Veenman, 1992), which have specific sets of "rules" that students can interact with (for instance a rule of the rock-cycle is that slow cooling of magma will always create plutonic rocks). The capability of the computer to store and run high quality animation enables such microworlds to provide students with vivid simulated experiences, which in many cases (such as with many of the rock-cycle processes) could not be experienced by other means. An additional decision was to design the activity as a game. Evidence exists indicating the effectiveness of playing on students' curiosity, divergent thinking and motivation toward learning diverse scientific topics (e.g., Shaw, 1983) and even on attitudes toward the environment (Henniger, 1987).

Following these considerations, the software "A Virtual Journey within the Rock

Cycle" was developed. This microworld game (Windows and Macintosh compatible) is aimed in assisting junior and senior high school students, who have already learned about the rock-cycle's processes and products, in developing a dynamic and cyclic understanding of the earth's crust system.

DESCRIPTION OF THE SOFTWARE

The software includes animation, photos, figures and verbal explanations considering the geological processes, the environments of formation and the rocks presented in table 1. Two versions are included in the kit, designed for different levels of knowledge. The senior high school version includes all the geological processes, the environments of formation, and the rocks included in table 1. However, since chemical concepts such as dissolution and crystallization from a saturated solution might still be shaky in the junior high school level, the evaporitic environment and product rocks are not included in this version. The assignment at this level is therefore, to collect only four rocks, instead of five rocks in the high school version.

When students enter the software, they are introduced with a background story, presenting Cosmo, a friendly alien that had to land on the earth from the outer space, due to loss of power produced from rocks. Cosmo is looking for replacement parts, made of rocks, in order to repair his spaceship. To assist him in this mission, the student gives him advice how to navigate within the earth's crust, by choosing geological processes, which bring Cosmo to different geological environments of rock formation.

In order to complete the mission, the student must assist Cosmo to collect five rocks (or four in the junior high school version), and throw away any extra rock, making the least number of moves within the rock-cycle, with a restricted amount of Methane for Cosmo's breathing. In order to collect a rock, the student must assist Cosmo in moving from one environment of formation to another, by choosing appropriate geological processes. This continues until Cosmo reaches the environment in which the student believes the specific rock is formed. When a rock is requested in the correct environment the student receives a positive feedback – Cosmo uses his geological hammer to brake a fresh piece of the desired rock and installs it in the spaceship. In cases when a specific rock is requested in the wrong environment, Cosmo receives the rock that is formed in that environment. If this rock is not included in the mission, the student will have to assist Cosmo to throw it away. However, the rock cannot be thrown away immediately, and the student will have to complete a whole cycle of geological processes in order to come back to the specific environment and get rid of the unnecessary rock. If by chance this rock is included in the mission, Cosmo receives the rock, but the student receives a "yellow card" for trying to pick a rock in a wrong environment. The game continues in this manner until either the mission is completed and Cosmo fixes the spaceship, or is stopped by the one of the following conditions: a) more than two yellow cards are received, b) Cosmo's Methane tank of 50 breath's is finished due to too many actions of the student..

Table 1: Rocks, geological processes, and environments of formation included in the software (as appearing in their simplified form used in the software)

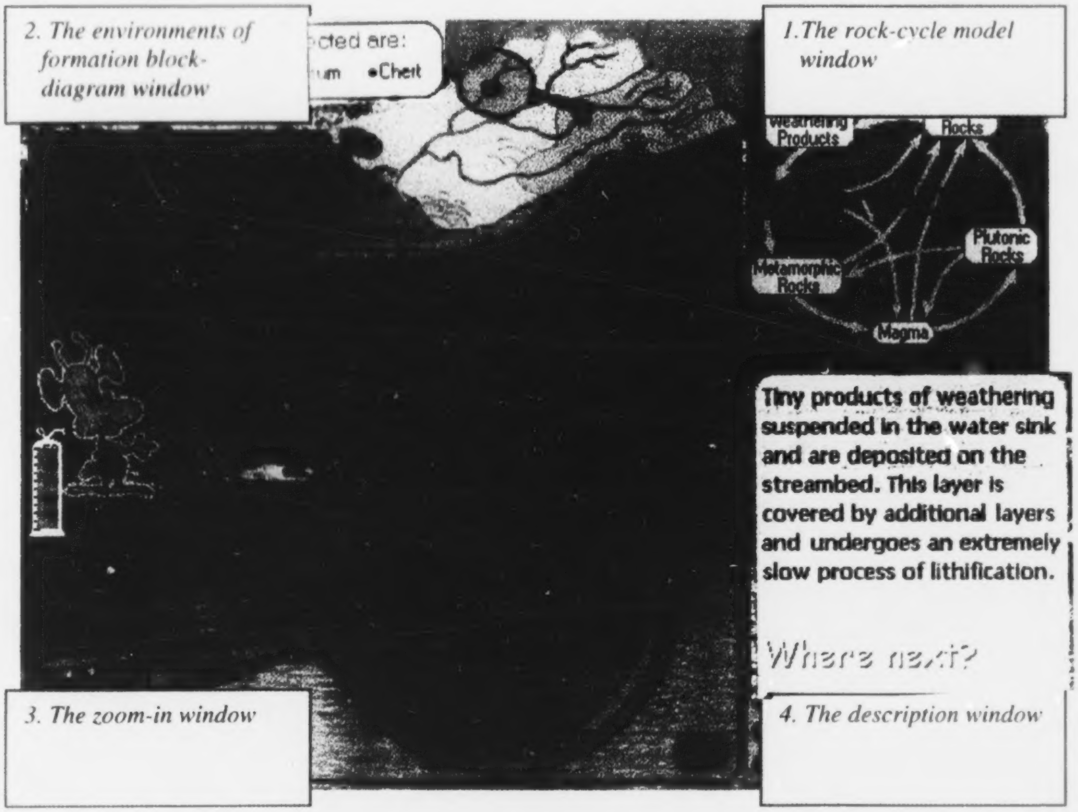
Rocks	*Geological processes*	*Environment of formation*
Magmatic rocks		
Granite	Slow crystallization of magma	Plutonic zone: pockets of magma in the earth's crust
Basalt	Rapid crystallization of magma	Volcanoes: Continental and mid-oceanic
Metamorphic rocks		
Gneiss	Burial and metamorphism of any rock*	High temperatures and pressure at the depth of the earth's crust*
Schist		
Sedimentary rocks:		
A) Biogenic rocks		
Limestone	Extraction of calcium carbonate from seawater by organisms, which build coral reefs and shells, deposition and lithification.	Shallow sea
Chalk	Extraction of calcium carbonate from seawater by forminifera, deposition of their shells, and lithification.	Open sea
Chert	Extraction of silica from seawater by radiolaria, deposition of their shells and lithification.	Open sea
Phosphorite	Accumulation of rich organic material deposits containing fish skeletons and teeth.	Fertile areas in the sea (upwelling)
B) Clastic rocks		
Sandstone**	Erosion of exposed rocks, transportation and deposition of sand grains by currents (steams or wind**)	Rivers; Dunes**
Marl	Erosion of sedimentary rocks, transportation and slow deposition of fine sediments.	Lakes and deltas
Clay	Erosion of magmatic and metamorphic rocks, transportation and deposition of fine sediments.	Lakes; Deep ocean
C) Evaporitic rocks		
Dolomite***	Evaporation and successive increase of salt concentration to the degrees appropriate for dolomite, gypsum, and halite to crystallize	Lagoon with limited seawater inflow and high rates of evaporation
Gypsum		
Salt		

* Distinction between the formation processes of schist and gneiss are not included.

** Distinction between the rocks that form in these environments is not included.

*** Dolomitization processes are not included.

The interface of the software includes the following four windows that appear on the screen throughout the whole game (Figure 1):


2. The environments of formation block-diagram window
cted are:
um •Chert
1. The rock-cycle model window
Weathering Products
Rocks
Plutonic Rocks
Metamorphic Rocks
Magma
Where next?
3. The zoom-in window
4. The description window

Tiny products of weathering suspended in the water sink and are deposited on the streambed. This layer is covered by additional layers and undergoes an extremely slow process of lithification.

Figure 1: The interface of the software including the four windows.

1) The rock-cycle model window (Figure 2): This window provides the student with a graphic diagram which includes all the geological processes (represented as arrows) and their products (represented as rounded rectangles), which together represent the cyclic system of the earth's crust known as the rock-cycle model. The student's route throughout the rock-cycle is constantly updated, and represented by colored arrows in the model, flashing the arrow of the last move. Pointing each of the arrows pops-up a tag of the geological process it represents, and pointing at some of the rectangles, pops-up tags with additional information of specific products. A "show route" button highlights the arrows according to the order in which they were entered by the student, counting his/her moves within the rock-cycle.

2) *The environments of formation block-diagram window (Figure 1)*: In this window all the environments of formation are illustrated in a block-diagram model. Such representation emphasizes the spatial relationships between the different environments. A magnifying glass indicates the location of the environment where Cosmo is found at any moment of the game.

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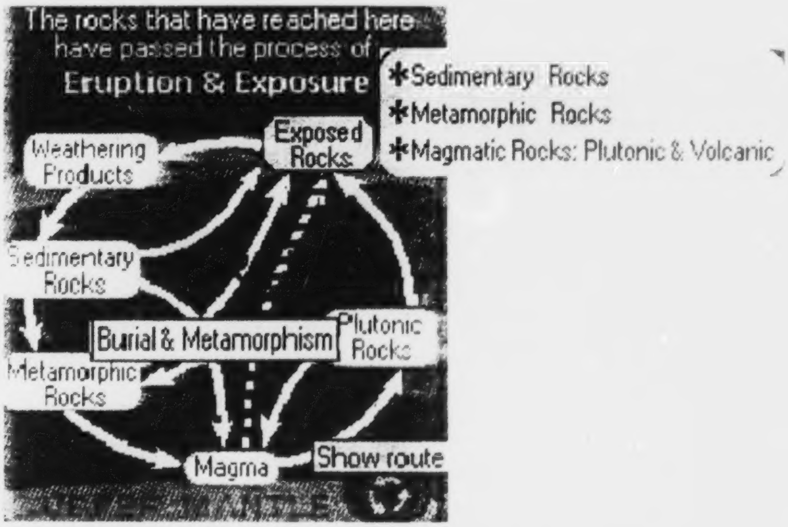

The rocks that have reached here have passed the process of

Eruption & Exposure

*Sedimentary Rocks
*Metamorphic Rocks
*Magmatic Rocks: Plutonic & Volcanic

Exposed Rocks
Weathering Products
Sedimentary Rocks
Burial & Metamorphism
Plutonic Rocks
Metamorphic Rocks
Magma
Show route

Figure 2: The rock-cycle model window

2) *The zoom-in window (Figures 3 and 4)*: This window illustrates the specific environment that is indicated by the magnifying glass of the block-diagram window. Each environment includes animation illustrating the geological processes occurring in the environment, and their products. For example, in the open sea environment, animation illustrates the sedimentation of foraminifera shells on the sea floor. Animation also illustrate geological processes, which transform materials between different environments of formation. For example, when the student chooses the process of burial and metamorphism, animation illustrates the alignment process of the minerals as the pressure and temperature rises, the processes (Figure 4a and 4b).

Figure 3: Animation in the zoom-in window: Example from open sea environment

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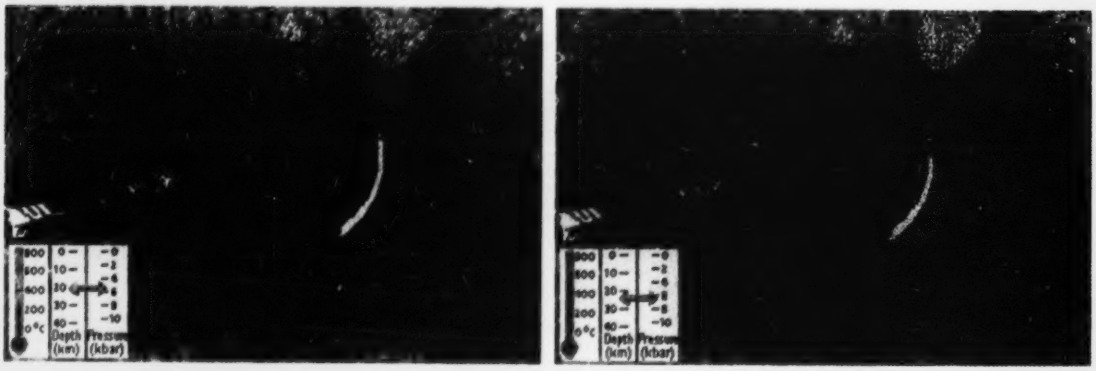
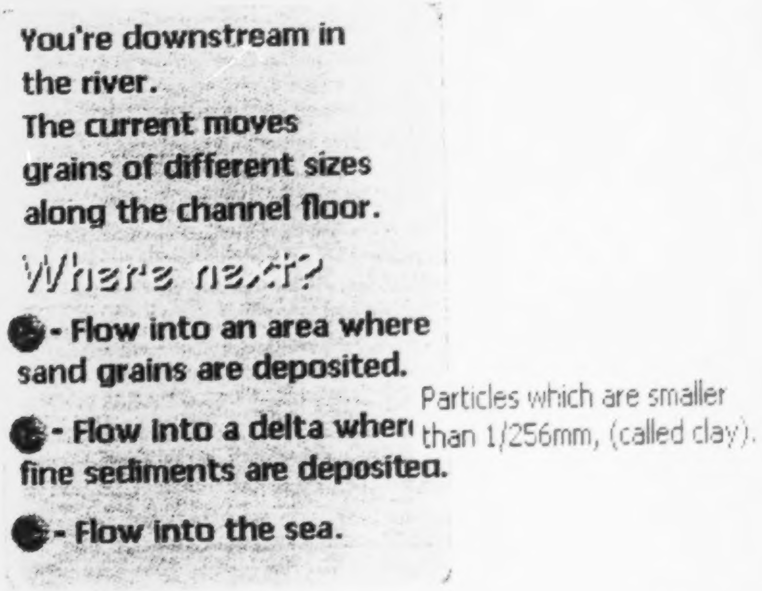

a) Beginning of animation *b) End of animation*

Figure 4: Animation in the zoom-in window: Example from metamorphic environment

4) *The description window (figure 5)*: In this window, the processes occurring in the zoom-in window, are described. At the end of each description, options are presented for navigation within the rock-cycle. The question "Where next?" is presented, with several navigation buttons representing geological processes that can act on the products of the specific environment. Clicking on any of these processes, models material transformation from the specific environment, to a new one caused by the geological process. Such modeling is represented by an update of all the windows to illustrate this transformation as follows:


You're downstream in the river.
The current moves grains of different sizes along the channel floor.

Where next?

● - Flow into an area where sand grains are deposited.

● - Flow into a delta where fine sediments are deposited.

● - Flow into the sea.

Particles which are smaller than 1/256mm, (called clay).

Figure 5: Navigation buttons and pop-up reminders in the description window

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a) A new arrow is added to the route represented in the rock-cycle model window.

b) The magnifying glass of the environments of formation block-diagram window moves to point on the new environment.

c) A new environment is illustrated with animation in the zoom-in window

d) A new description of the environment appears in the description window, with newoptions for further navigation.

Many terms, which are usually novel to students before learning about the rock-cycle, are used in these explanations. Since the software is designed as a knowledge integration concluding activity, and not as means for primary learning about geological processes, such terms are not extensively discussed. However, in order to encourage students to concentrate on the dynamic and cyclic aspects of the rock-cycle, rather than on newly learned terms, pop-up tags are used as reminders of the meaning of such terms.

PEDAGOGICAL CONSIDERATIONS IN THE DESIGN PROCESS

The restrictions in the rules of the game, designed to add an element of excitement, are actually a result of pedagogical considerations based on the study about systems-thinking in the context of the rock-cycle (Kali, Orion, & Eylon, 2000). For instance, restricting the number of moves in the rock-cycle, and the number of Cosmo's breaths, is aimed in motivating students to carefully plan Cosmo's route within the rock-cycle, rather than proceed in a trial and error route. It is suggested that such planning of cyclic routes of geological processes might assist students in developing systems-thinking in the context of the rock-cycle.

Another example is the restriction on the number of yellow cards permitted in the game. This rule, which also has a motivational effect, is aimed at preventing students from guessing, and encouraging them to recall the pieces of knowledge previously gained about the rock-cycle, and integrate these pieces into a holistic view of the system.

An additional decision was the number and the types of rocks to be collected in a single mission. The decision to require five types of rocks (one of each rock-category), was aimed to encourage the student to pass several cycles within the system (at least three cycles are needed in order to compete any mission). In this manner students can construct long sequences of processes and products, a process that might assist them in developing the systems perception of the rock-cycle.

The design of the interface in four windows that are mutually present on the screen during the whole game, is based on the notion that multiple visual representations are beneficial in illustrating complex ideas (e.g., Linn, 2000). Although all four windows reflect the location of Cosmo at any moment within the rock-cycle, each window emphasizes different types of information.

The "rock-cycle model window" provides information of the rock-cycle, emphasizing the relationships between different geological processes, and the sequences of processes creating material transformation within the rock-cycle. Apparently, this window provides all the information needed for understanding the dynamic and cyclic nature of the system. However, evidence exists that students who studied the contents of the rock-cycle and were able to draw this model did not necessarily internalize it's dynamic and cyclic aspects (Kali, Orion, & Eylon, 2000). The symbolic information of this window is therefore supported by the other three windows.

The "environments of formation block-diagram window" provides the student with lively graphic information illustrating the various environments of formation, and of the spatial relationships between them. The movements of the magnifying glass between these environments might assist students to perceive the material transformation within the earth's crust more realistically than the symbolic information of the "rock-cycle model window".

The two windows described above present general information about geological processes. The "zoom-in window", and the "description window" enable students to focus on the details of processes occurring in specific environments of formation. For example, the successive processes of evaporitic crystallization, is represented by the general term "sedimentation" in the "rock-cycle model window", or as a general illustration of a lagoon the "environments of formation block-diagram window". Such processes are described in detail and illustrated in the "description window" and the "zoom-in window". It is suggested that the illustration of such processes, and their verbal description, together with the other more general windows, could enable students to relate processes in specific environments to a more general view of material transformation within the rock-cycle.

IMPLEMENTATION AND PRELIMINARY EVALUATION

The software "A Virtual Journey within the Rock Cycle" was implemented in several junior and senior high school classes. Our preliminary observation indicate the following points:

a. The software aroused great enthusiasm amongst students:
   - Students tended to enter the game many times in order to achieve higher scores, competing with themselves and with other students.
   - Many students chose to remain in class and continue playing at the expense of their free time.
   - Many students asked for a copy of the software, in order to continue playing at home.
   - Students' remarks showed excitement and enthusiasm.

b. The software fostered collaborative group work amongst students. This was shown by the fact that although students had the opportunity to work individually, in many cases, they chose to work in groups of two or three students. In such cases many of students' discussions were aimed on better understanding of the contents of the software by mutual discussion with their peers.

c. The interaction with the software encouraged students to recall previously learned knowledge. In order to complete the mission in the least number of moves, many students opened their booklets, and considered their answers to questions related to laboratory experiments illustrating geological processes.

d. A general pattern characterized the progress of many students while working with the software. This pattern included preliminary "trial and error" playing, without paying attention to most of the information provided by the different windows of the interface. Students concentrated on the "Zoom-in" window, and the navigation buttons of the "description window", and tended to ignore the "rock-cycle model window" and the "environments of formation block-diagram window". Therefore, they were not engaged in planning their journeys. It is suggested that this pattern of interaction, which in many cases resulted in losing the game, could not foster systems-thinking amongst students. However, this stage was in most cases, followed by a more sophisticated interaction stage, in which students wisely used the interface of the software for planning their journeys throughout the rock-cycle. Although some of the students reached this stage independently, motivated by the software's feedback, in other cases the teacher assisted them in reaching this stage.

e. The teacher's role as a mediator was substantial. When the teacher's mediation was needed, he/she directed students' attention to the model of the rock-cycle, in which their moves were documented by colored arrows, and to the block-diagram illustrating the spatial relationships between the environments which they had passed though. The teacher encouraged students to plan their journeys, using this information. It is suggested that this mediation was crucial in their ability to exploit the pedagogical and affective potential of the software.

A further study is planned in order to a) reexamine the preliminary findings, b) find optimal manners of implementing the software, and c) assessing its effect on students' systems thinking in the context of the rock-cycle.

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Historical Approach to Studying Plate Tectonics "Drifting Continents and Colliding Theories" Program

Ron Ben-Shalom and Nir Orion,
Weizmann Institute of Science, Rehovot, Israel,
ntron@wisemail.weizmann.ac.il

Introduction – "Science for All" and Plate Tectonics

Our era in science education is characterized by a paradigmatic shift towards the "Science for All" paradigm. The main goal of science education shifts from educating and preparing future scientists towards the education and preparation of future citizens.

The earth sciences can serve as a very powerful venue in this direction since they include many subjects that have a strong relevance to our ability to live in peace with our physical environment. One of the most important subjects in the earth sciences is the Plate Tectonics Theory, which involves geological phenomena such as earthquakes, volcanic eruptions and tsunamis. Thus an understanding of phenomena is crucial for fields such as urban planning and building constructions.

The cognitive obstacle

The learning of Plate Tectonics involves dealing with geological processes that occur on a very large scale, in very slow rates and in the depth of Earth. As a result, direct observations are not possible and laboratory simulations are of little help for the same reasons. Thus, learning this subject requires the overcoming of several cognitive obstacles such as high abstraction ability and orientation in time and space.

The historical approach

The development of the presented curriculum was preceded by a predevelopment study. One of he most predominant findings of this study, which was strongly supported by the literature review, is that the preconceptions of novices are very similar to the scientific perception held by nineteen–century scientists. Therefore, it was decided to develop the "Drifting Continents and Colliding Theories" program in an historical approach.

Historical approach to science teaching is a well–known learning strategy that was implemented in all the scientific disciplines. This approach is based on the notion that the way thinking develops in young learners parallels the development of scientific thought throughout history.

Furthermore, conceptual change of students perceptions is a very difficult process and again can be compared to the difficulties scientists had along the history to change their paradigms. We suggest that studying the theory of Plate Tectonics parallel to its historical evolution might contribute to deeper understanding of its concepts, and help learners to overcome their preconception and misconceptions.

Plate tectonics as a vehicale to study the nature of science

The revolution of Plate Tectonics is the most recent revolution in scientific knowledge. Since it occurred in our time, its history provides a unique opportunity for learners to examine science's philosophical dimension. The story of Plate Tectonics forms an excellent framework for studying topics such as creation and accumulation of scientific knowledge, and scientists' preference of one theory to another. Studying philosophy of science in such concrete context contributes to a better understanding of the essence of science, and helps learner to develop a more realistic images of science and of scientists. True understanding of the issues mentioned above is very important for citizens in modern society because it enables them to judge and evaluate information given by scientific sources, and to keep a balanced proportion of media items.

Learning strategies and learning environments

"Drifting Continents and Colliding Theories" implements a constructive strategy to lead learners through conceptual changes. Learners' early knowledge and preconceptions are unveiled first, and are taken into consideration while handling new data. Then, New sets of observations are presented in a series of self–inquiry activities. These observations sometimes lead to opposing sets of arguments. They are presented in the same chronological order according to which scientists made them. Every set of new data creates cognitive conflicts among learners. These cognitive conflicts parallel the ones scientists faced in the past. They help learners, who are involved actively in the process of learning, reevaluate and reconstruct their personal concepts. Presenting the learners with opposing sets of arguments (e.g. contructionism versus permanentism, magnetic polar wandering versus continental drift, polar reversals versus chemical alteration), enable them to analyze the data and therefore sharpen their cognitive skills, and develop a better understanding of the way in which scientific knowledge is created.

Learning environments include laboratory, computers and the outdoors. Since the subjects taught are very abstract and because of the difficulties mentioned earlier, the use of visual aids and simulations is required. While constructing Wegener's Continental Drift, the use of detailed pictures of the different evidence he examined and maps showing the places where they were found, contributes to better visualization of the data. Simulation experiments are used for construction of physical concepts such as mantle convection and geomagnetics. A magnetic globe model helps to demonstrate the properties of Earth's magnetic field including the significance of inclination, which is difficult to understand. The computer is used basically for simulation of abstract processes and concepts, which are not easy to simulate in the lab. For example: magnetic polar wandering; magnetic reversals; the contribution of seismic waves to understanding the inner structure of Earth. Internet sights monitoring earthquakes and volcanic activities throughout the world are used for collecting the important data about those phenomena.

Field trips are very important components in a constructivist geological program. For the Israeli education system there are two good options for field trips to areas representing plate boundaries. The first option is immediate: the transform fault of the Dead Sea rift, which forms a very prominent landscape, and which parts of the fault provides possibility to measure the rate and amount of offset. The second one is a forty minute flight away– the ophiolite in the Trodos mountains in Cyprus, that represent what once used to be an oceanic ridge.

Implantation and evaluation

The program is now implemented among few high school classes. This implementation is followed by an formative evaluation which its preliminary findings will be included in the poster.

The Carbon Cycle and the Earth Systems – Studying the Carbon Cycle in Multidisciplinary Environmental Context

Yossi Gudovitch and Nir Orion,
'Weizmann Institute of Science, Rehovot, Israel
Yossi.gudovitch@weizmann.ac.il

INTRODUCTION

During the last two decades the public has been exposed through the mass media to a lot of global environmental issues such as the increased greenhouse effect, depletion of the ozone layer and water pollution. As a result of our era of information disclosure, public awareness toward these topics has increased, as well as the awareness that human activity might cause damage to the natural systems and that such damage might in turn have a negative effect on the human population. However, the information provided through the mass media is often biased and even incorrect, thereby contributing to the development of misconceptions concerning environmental issues (Brody, 1994).

One of the results of the growing public awareness of these topics was a demand for more scientific research concerning global and regional environmental issues. This demand was followed by a change in the public's perception of the earth sciences: from a disciplinary approach (with a distinction between geology, hydrology, atmospheric science, oceanography, etc.) to a multidisciplinary approach, studying the interaction between the different earth systems as well as between the natural systems and human activity.

The change that took place within the scientific community had a major effect on science education as well. Consequently, many scientific curricula dealing with environmental multidisciplinary topics have been developed. However, the curriculum developers have had to confront the many alternative frameworks that students bring to the classroom as the result of a non–mediated exposure to the mass media.

This article describe a method that attempt to confront the challenges of developing an environmentally based earth sciences program.

THE RESEARCH SCHEME

The research scheme includes the following five stages: predevelopment study, curriculum development, implementation, formative evaluation, and curriculum modification.

The predevelopment study: The objectives of the predevelopment study are as follows: (a) to choose a scientific multidisciplinary topic with a distinct connection to global environmental problems, (b) to select the specific themes for the program, and (c) tó learn about student's previous knowledge, perceptions, and misconceptions concerning environmental problems in general and, the selected topic in particular.

In order to achieve the two first objectives the environmental educational literature was thoroughly reviewed, followed by several interviews with earth and environmental sciences researchers. Importantly this study revealed that multidisciplinary topics concerning biogeochemical cycles might serve as an ideal model for illustrating the interactions among the various earth systems and between them and man. Subsequently, it was later decided that the current study will focus on the Global Carbon Cycle (GCC).

In order to achieve the third objective, data concerning students' previous knowledge and interest in environmental topics was collected using Likert–type questionnaires and interviews. This study examined a high school population of about 70 students and its main findings were as follows:

a) Students declared high understanding of environmental problems and biologic processes. For example, global warming (mean of 3.3 in a 1–4 scale, S.D=0.8), climate change (M=3, S.D=0.8), ozone layer (M=3.1, S.D=0.9), and photosyntesis (M=3.7, S.D=0.5).

b) Students declared only partial understanding of more abstract topics connected to these environmental problems such as earth radiation balance (M=2.3, S.D=1), greenhouse gases (M=2.5, S.D=1), and albedo (M=2.6, S.D=0.9).

c) Most of the students understood that global warming is connected to the greenhouse effect (mean of 3.7 in a 1–5 scale, S.D=1).

d) Most of the students thought that greenhouse effect is directly connected to depletion of the ozone layer (M=3.7, S.D =1.1).

The interviews indicated that students hold the following alternative framework: the "hole" in the ozone layer allows more radiation to enter the atmosphere and then it was trapped by the greenhouse effect. Global warming is the result of the combination of these two elements: the hole in the ozone layer and the greenhouse effect. A similar findings were reported by Boyes & Stanisstreet (1993), Francis et al. (1993), Christidou (1994), Rye et al. (1997), and Boyes & Stanisstreet (1997).

The results described above show that students are aware of the environmental problems, but, on the other hand, their knowledge is very limited. This contrast supports Orion (1997) who claimed that the environmental problems are just symptoms of the real problem: the effect of human activity on natural balance among the earth systems.

These findings suggest that the environmental aspects of the carbon cycle are related to the student's daily life; however, any program that deals with such a topic should take into account that students would enter such a learning experience with some basic alternative conceptions.

CURRICULUM DEVELOPMENT

Program development was based on the constructivist (student–oriented) approach. The curriculum was built around the following three sub–units:

The Core Unit: The purpose of this unit is to provide students with a complete and balanced picture of the GCC. The first part of the program deals with the most obvious environmental topic that students are most aware of – the greenhouse effect and increased atmospheric CO_2. One of the objectives of this part is to demonstrate that in order to understand the atmospheric CO_2 balance all of the four natural earth systems: geosphere, hydrosphere, atmosphere, and biosphere must be considered, in addition to human activity.

In order to deal with students' alternative models, the core unit uses the cognitive conflicts strategy (Nussbaum & Novick, 1982). Cognitive conflicts are the result of additional information that does not fit students' previous knowledge and consenquently forces students to rearrange their knowledge and gradually enhances their perceptions of GCC.

Two additional learning materials were developed for the core unit. (1) a booklet that directs students' investigations through activities and (2) a booklet for scientific critical reading including popular articles, with directions ffor critically reading them.

The Individual Projects Unit: In this unit each student or group of students has to select one of the components of the GCC that they encounter in the "Core" unit and to elaborate it through self study the literature.

Geotop: This unit is based on a field study of the components of the carbon cycle that appears in a karstic cave in the Judean mountains. The learning is conducted as a "team–self" project, While each team of students has to identify a research question and to study it based on field observations and laboratory analysis.

IMPLEMENTATION

The new curriculum was implementated with 11th and 12th grades high school classes that participated in the program as part of the fulfillment of their earth sciences matriculation program of 5 credit point. The specific study population included one class of 15 students from a typical urban high school.

THE STUDY

The implementation of the whole three units of the new curriculum was followed by an extensive study. Our literature review identified few publications with some educational aspects of studying environmental issues in general and the global warming effect in particular (Wadingtton, 1994. Rubba et al, 1995. Fortner & Mayer, 1993. Bolden et al, 1991) However, no references were found concerning the cognitive aspects of learning and understanding complex and abstract topics such as biogeochemical cycles. Thus, the main purpose of this study was to shed some light on students' abilities and their difficulties in perceiving the dynamic and cyclic transformation of matter and energy among the different earth systems and the interactions among them. Since we had almost no reference on which to base our study, the current study was mainly phenomenological. Therefore we developed a research strategy that we named the "Fishing net" approach. The idea behind this approach was that dealing with a subject not yet explored is like fishing in a dark water and therefore in order to "catch" some meaningful insight the best strategy is to use a wide net with small holes in a relatively small area. Thus, in order to extend our ability to collect meaningful data, we based our study on a variety of qualitative and quantitative research tools, which operate on a relatively small sample. Fourteen different inventories were specialy developed for this study. In addition, the data were collected and analyzed through a "zoom in" method, namely from a level of the class as a whole to the level of the small groups of students that worked together as teams throughout the whole learning process to level of the individual student. This research structure enabled us to identify many dependent and independent variables that might affect the learning process. The quantitative tools enabled us to collect and analyze data in relation to the population studied as a whole, whereas the qualitative tools enabled us to detect cognitive processes within the level oof the individual (Denzin & Lincoln, 1994). The combination of the two methods allowed us to triangulate data collected by different tools and to increase the reliaibility of our findings and conclusions (Fraser and Tobin, 1992).

Table 1 describes 8 questionnaires out of the 14 inventories that were specially developed for this study. These research tools examined aspects such as knowledge and understanding of components and processes of the GCC, perception of systems, understanding the interactions among earth systems, understanding the principle of mass conservation and the quantitative perception of GCC. The tools include different types of questionnaires, namely closed (Likert type), open and matching, and were filled in by the students before (pre) and after (post) the implementation.

At the end of the core unit a cognitive test was conducted. It tested students' cognitive skills of critically reading a popular scientific article concerning environmental issues, analyzing models of GCC, and presenting matter (carbon) transformation within the earth systems. The last assignment provided a broader picture of students' knowledge concerning the processes of matter transferred among the different earth systems. Students were asked to describe two paths (continuity of processes) that transfer Carbon between two given points in earth.

The content validity of all the inventories used by this study was evaluated by 5 experienced researchers. Two of them were experts in earth science and environmental education, two were experts in science education in general, and one was a expert in environmental sciences. The construct validity of the differenet inventories was tested by the following procedures: (a) comparing the content of the inventory's items with the syllabus of the program and (b) reviewing the thinking skills level needed for answering those questions according to Bloom's taxonomy (Bloom, 1956).

Table 1: description of 8 out of the 14 questionnaires.

Questionnaire	Description	Type of questionnaire	Pre	post
Earth systems mass	Students were asked to assume the partial mass o each of the earth systems.	Likert (1-6) (1=<1% 6=>50%)		√
Mass change	Students were asked to answer whether the listed processes change earth mass.	Likert (1-2 / 1-3) (1=no change 3=major change)*	√	√
Carbon in earth systems	Students were asked to assume the distribution of the carbon among earth systems.	Likert type (1-6) (1: <1% 6: >50%)	√	√
Greenhouse effect	Student's agreement with statements concerning the greenhouse effect.	Likert (1-5)	√	√
Balance in earth systems	Student's agreement with statements concerning interactions between earth systems.	Likert (1-5)	√	√
Consequence of the greenhouse effect	Students were asked to describe the effect of increased atmospheric CO_2 on natural earth systems.	Open		√
Knowledge	Students were asked to describe their knowledge of concepts concerning GCC and environmental issues.	Likert (1-5)	√	√
Atmospheric CO_2	Students were asked whether the listed processes change atmospheric CO_2.	Likert (1-2 / 1-3) (1=no effect 3=direct effect)**	√	√

* In the pre test there were only 2 options (1–no change, 2–change). After analyzing students' pre questionnaires and interviews, the answer changed (1–no change, 2–minor change, and 3–major change).

** In the pre test there were only 2 options (1–no effect, 2–effect). After analyzing students' pre questionnaires and interviews, the answer changed (1–no effect, 2–not direct, and 3–direct effect).

The qualitative research tools included observations of the students during their learning process and interviews with several students.

The comparisons between pre and post data collected by the different questionnaires provided information about changes in students' knowledge and perceptions, whereas the final exam analysis provided a more precise picture of students' knowledge at the end of the program. The analysis of observations provided information about each individual student's behavior and participation in class and the interviews provided a deep understanding of the cognitive perceptions of individual students in the context of the interrelationship between the different earth systems.

DATA ANALYSES

The qualitative data collected was used to observe the changes in students' knowledge and perceptions. A wilcoxon non–parametric test was used to between the pre–test and the post–test of the Likert–type questionnaires. Students' answers to the open–

ended questionnaires were categorized and then the distribution of each category was analyzed quantitatively. In order to identify differences between individual students, a mean score was calculated for each student in relation to each of the questionnaires. These values were classified acoording to three levels: low, medium, or high (Table 2). This technique was found effective in pointing out differences between students and useful in spoting students' difficulties in relation to a specific category or subject.

Table 2: An example of the data analysis in showing differences between different students in relation to a specific questionnaire.

1	2	3	4	5	Student no.
2.2	2.4	1.8	1.9	2.1	Pre
3.2	2.8	**3.4**	2.9	2.9	Post

Low score | Medium score | **High score**

The final exam was evaluated according to the criteria that were defined for each of the questions, and students' answers were categorized and analyzed similarly.

Each process of categorization and matching of a student's answers to the different categories in relation to each of the inventories was validated by three experts in science education.

RESULTS

Global environmental problems

The comparison of the pre and post data of the "knowledge questionnaire" indicated a significant increase of students' declared understanding, after the core unit, concerning concepts related to GCC and the greenhouse effect. However, no change was detected concerning their declared knowledge of other environmental problems such as depletion of the ozone layer.

The analysis of the "greenhouse effect questionnaire" and the final exam indicated a significant change in students' perceptions of the role of man in creating the greenhouse effect. After the core unit, most of the students understood that the greenhouse effect is a natural phenomenon, which is affected by human activity. They were also aware of the fact that the degree of the effect is still unknown. These findings indicate that students' assumptions regarding the role of man with natural processes became more realistic. Table 3 shows a meaningful improvement of students' knowledge about the processes that emit CO_2 into the atmosphere. The major change found was regarding the effect of the geologic processes (element 3) and the change in the total biomass (element 4) on atmospheric CO_2.

No significant improvement was found concerning students' perceptions of the relation between the greenhouse effect and the depletion of the ozone layer.

Table 3: Results of the pre/post analysis of the "Atmospheric CO_2" questionnaire (N=15).

How would the processes listed below affect atmospheric CO_2 concentration?					
	Pre test		Post test		
	No effect	Effect	No effect	Indirect effect	Direct effect
1. Fossil fuel burning	20%	80%	0%	7%	93%
2. Industry and power stations	20%	80%	0%	0%	100%
3. Volcanic eruption	47%	53%	0%	13%	87%
4. Forest fires	27%	73%	0%	7%	93%

Processes in the global carbon cycle

A clearer picture was obtained concerning students' understanding of specific processes after studying the core unit obtained from the analysis of the "matter transfer" questionnaire. Table 4 presents students' results concerning "volcanic eruption" (one out of four processes that appeared in the questionnaire). Volcanic eruptions are those processes that emit matter from the geosphere. The matter emitted is molten rocks (back to the geosphere) and different gases (into the atmosphere and/or to the hydrosphere). Student's results indicated that they tend to overemphasize the role of the atmosphere as a sink compared to other earth systems. These results indicate that students are more aware of the effect of different processes on the atmosphere but their knowledge about the effect of those processes on other earth systems is limited.

Table 4: Results of the "matter transfer" questionnaire (n=15).

Volcanic eruption	To the hydrosphere	To the geosphere	To the biosphere	To the atmosphere	Total*
From the hydrosphere				1	1
From the geosphere	4	7	2	13	26
From the biosphere					0
From the atmosphere					0
Total*	4	7	2	14	

* Students could choose more than one answer.

The analysis of students' answers to their assignment of describing the paths (continuity of processes) that transfer Carbon between two given points in two separate earth systems reveals the following:

→ Students describe respiration by marine organisms as a process that emits CO_2 directly into the atmosphere.

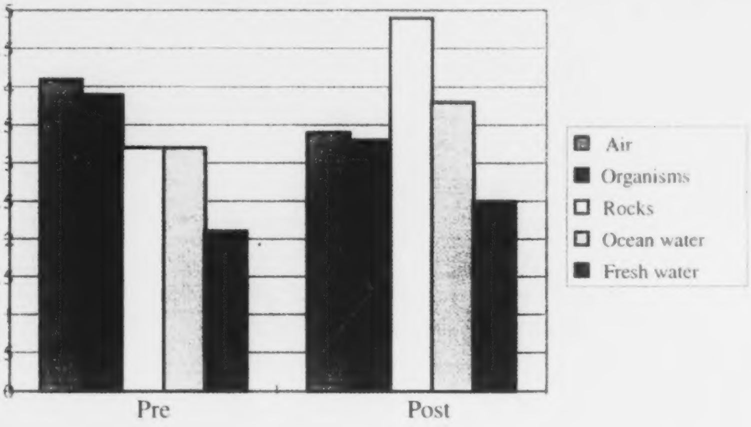
→ For example, students used the diffusion process to describe the flow of carbon from the atmosphere into the ocean, but no student used this process to describe the flow of matter in the other direction. In order to explain this finding, it is important to note that the core unit included an experiment that demonstrated the diffusion of CO_2 from air into water. However, the reverse process was only mentioned orally and was not demonstated through active lab activity. This finding indicaate that students have difficulty in transferring knowledge from one situation to a similar one. Thus, the program should include more concrete demonstrations and after the concrete learning, more emphsis should be given to teach basic physical and chemical processes such the "Le Chatelye" principle.

→ Only a few students succeeded to integrate in their descriptions a path that crosses the hydrosphere (water cycle) and the geosphere (rock cycle).

These results indicate that most of the students have difficulties understanding abstract processes in GCC and only a few students are aware of the relationship of GCC and other global cycles.

Carbon reservoirs in earth systems and the mass of earth systems

Figure 1 demonstrates the mean scores of students' answers of the "carbon in earth systems" questionnaire that was administrated to explore the effect of the program on students acquaintance of the carbon reservoirs on earth. indicates an improvement of students' perceptions of the relative sizes of the different carbon reservoirs on earth. At the pre test no student ranked the rocks as the biggest carbon reservoir, whereas in the posttest 40% of the students ranked rocks as containing more than 50% of the carbon on earth. The number of students who showed a totally different view in relation to scientific reality dropped from 60% to 47%. The comparison between the pre test and the posttest, using a Wilcoxon matched paired test showed a significant change only in students' perceptions of the relative size of the rocks as carbon reservoir. However, it is important to note that even in relation to this improvement, the students' perceptions are still very far from the scientific fact that the rocks contain more than 99.9% of the total carbon.



Percent of total earth carbon in each system
<1% (1)
1-5% (2)
5-10% (3)
10-25% (4)
25-50% (5)
>50% (6)

Figure 1: average students answers to "Carbon in earth systems" questionnaire

A comparison between students' answers to the "Carbon in earth systems" questionnaire and the "Greenhouse effect" questionnaire were conducted using a non–parametric correlation Kendell test. This analysis showed a significant correlation between the pre tests of these two inventories as well as between their post test data. These findings indicate a similarity in students' previous knowledge toward these topic and a similarity in the effect of the program on them.

A triangulation between the results of these two questionnaires and the results of the "earth system mass" questionnaire that explored students' perceptions of the partial mass of each of the earth systems indicates the following:

→ Fourty percent of the students ranked the rocks as the biggest carbon reservoir and the geosphere as the biggest earth system. However, only 20% of the students had correct scientific knowledge in all of the questionnaires.

→ Sixty percent of the students overemphsized the biosphere mass and/or the carbon reservoir in the biosphere. They perceived the biosphere mass as equal to or bigger than the geosphere or the hydrosphere.

Interaction between earth systems

A deep understanding of the carbon cycle, especially in the context of environmental issues, must include an understanding of the interactions between the cycles' components, namely the reservoirs and the processes. The "Balance in earth systems" questionnaire was given to explore students' awareness and understanding of the natural processes that balance the amount of carbon in the different earth systems. Students had to judge seven statements such as "the amount of water in the ocean gradually increases because rivers keep adding water to it" (7% failed to answer in the pre test) and "increased annual precipitation in the our region will cause an increase in the Mediterranean Sea level" (40% failed in both pre and post test). A Wilcoxon Matched Paired test revealed no significant change between the pre and post tests.

In the "Consequence of the greenhouse effect" questionnaire students were asked to describe the effects of an increased atmospheric CO_2 level on different earth systems. The students tended to describe changes in the CO_2 level as a result of increased temperature. Most students mentioned effects on the biosphere (66%) (death of animals) and on the hydrosphere (53%) (enhanced evaporation). Only a few students mentioned the possible effect on geologic processes such erosion and sedimentation (27%) and on oceanic CO_2 concentration (13%).

The role of man in natural systems

The analyzing of the interviews indicated that at the end of the learning, students said that their knowledge about human activity on natural systems is more realistic. On one hand, students believe that man should reduce his effect on the natural systems, but, on the other hand, students understand that, in a geologic time scale, the effect is negligible. Students also understand that all different environmental problems will affect the human population.

These results enable evaluating the effect of the program on students' knowledge according to the whole class average. Table 5 shows a more detailed analysis of the final exam results and compares individual students. Results indicate the students' final grades, which was all in the narrow range of 72–89. Comparisons between individual students' achievements in different parts of the exam and between different students in the same part show that there is no correlation between different parts of the exam. A comparison between different parts, using a non–parametric correlation Kendell test indicates a significant correlation (0.51 p=0.04) only between the first two parts. The wide variability of students' grades and its distribution along the different parts of the exam indicates that the learning process is an individual process and each student internalized different topics differently.

In order to get a more accurate picture about the effect of the program on the individual, three case studies of individual students were conducted and analyzed.

Student A (No. 14 in Table 5): The knowledge of this student about specific topics taught in class was improved and her perceptions of earth systems and processes in the carbon cycle approached the scientific knowledge. She views the effect of human activity as a factor that affects natural balance, but according to questionnaires, she has not internalized the topic of natural balance. This student has difficulties in transferring principles she had learned in the context of a specific topic under different conditions. She has difficulties in seeing the broad, complex picture of earth and earth systems. This is expressed by difficulties in focusing on a specific topic from the broad pictures and by the fact that she has not internalized the principle of matter conservation in the context of earth.

Table 5: The distribution of students' grades in the final exam (n=15).

Student No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average	S.D.
Part a	12	12	12	12	**18**	12	12	12	12	12	12	12	12	**18**	12	12.8	2.1
Part b	20	22	20	18	**23**	21	18	17	**24**	20	15	**24**	21	**24**	22	20.6	2.7
Part c	15	**22**	**22**	**21**	20	18	17	**21**	**22**	18	**22**	20	18	20	**22**	19.9	2.2
Part d	25	27	26	23	27	**30**	**29**	26	**31**	**32**	28	**29**	22	21	21	26.5	3.5
Final grade	**72**	**83**	**80**	**74**	**88**	**81**	**76**	**76**	**89**	**82**	**77**	**85**	**73**	**83**	**77**	**79.7**	**5.3**

Student B (No. 11 in Table 5): The final exam and questionnaires of this student presented a relatively high level of knowledge. According to questionnaire results, his knowledge improved during the learning period. His achievements were most remarkable in the questionnaires dealing with balance and the interactions between natural earth systems. The interview supports this finding and reveals student perspective: the complexity of the whole system exited him. On the other hand, his knowledge concerning specific processes was quite poor.

The data analysis at the individual student level supports the finding about the variability between students, and adds another perspective: some students tend to focus on specific parts of the whole systems whereas others tend to concentrate on the full picture.

Discussion

The research results indicated that the program contributed to meaningful learning in relation to the GCC and to the achievement of the cognitive goals concerning earth systems as well as to the role of man among natural systems. Note that meaningful learning occurred mostly in the processes demonstrated in class using student–centered activities. The results support the effectiveness of using the constructivistic approach and a variety of teaching and learning strategies.

Two types of alternative frameworks (misconceptions) were identified by this study:

- Knowledge–related misconceptions. For example, the notion that the depletion of the Ozone layer influences global warming. In this misconception the advantage of using a constructivist teaching strategy focused on the specific topic.
- Perceptional misconceptions. For example, viewing the atmosphere as the biggest Carbon reservoir in comparison with the other earth systems. This misconception illustrates that more qualitative activities should be developed and integrated in the program.

Many students showed difficulties in transferring knowledge about processes of matter transfform between liquids and gas, to other exchange processes.

These difficulties illustrate the need to enhance students' background in chemistry and physics.

The results indicate a great variance between students' knowledge, understanding, and the ability to perceive the earth as a whole system. Based on these findings, four levels of system perception were identified:

- Level 1: **Knowledge** about the earth system's components and awareness of the connections (the transform of matter and energy) between them.
- Level 2: **Understanding** the exchange processes among various materials, between the systems.
- Level 3: Preceiving the interrelationships among the earth systems.
- Level 4: Preceiving the earth system as a unified whole.

It was found that there are three critical factors for achieving a unified system perception: (1) perception of an interrelationship between sub–systems, (2) the ability to perceive the cycling nature of materials on earth (also known as the principle of mass conservation), and a qualitative perception of size, rate, and quantity in relation to the earth systems.

Most students increased their knowledge and understanding in levels 1 and 2.

However, only two students achieved levels 3 and 4. Note that those two students did not get the highest scores in levels 1 and 2.

The findings regarding the hierarchical structure of unified system perception indicate that this perception is probably not knowledge related.

Note that this research should be considered pilot research because of the small target population and the fact that research tools were modified during the study.

This study contributed to following major areas:

A. The development of a meaningful interdisciplinary educational program dealing with four earth systems. importantly the teaching strategy demonstrated in this study can be applied to other "cyclically related" earth science and environmental topics.

B. The defining the primary factors that might affect students' ability to perceive a unifying system.

C. The identification of several important research questions that should be explored on a larger population.

D. The development of research tools that also should be tested on a larger population.

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The Role of Scaffolding in Environmental Decision Making in Synchronous Learning Environments

Kai Pata and Tago Sarapuu, University of Tartu, Estonia
kpata@ut.ee, tago@ut.ee

INTRODUCTION

One of the favourite realms in teaching decision–making process is environmental education. It provides a good mechanism for developing cognitive skills, social abilities, attitudes and values by offering real problems that can be simulated or studied (Howe et al., 1989). Environmental decision making and developing workable solutions to environmental problems requires making choices and decisions by examining information and opinions critically. In the process of environmental judgements the decision–maker has to consider scientific knowledge, as well as the aspects of legislation and economy but also ethical and moral issues to make competent decisions (Zandbergen & Petersen, 1995). Therefore, collaborative role–play gives a good opportunity for developing students' environmental decision–making skills. Synchronous computer–supported collaborative learning (CSCL) environment, in which all the participants of the discussion are simultaneously online and communicating in "real time" can serve as collaborative workplace for role-play, where learners can establish their common beliefs and build up shared knowledge on the dimensions of the problem. It can also provide learners with different kinds of scaffolding.

The theory of scaffolding has been derived from the views of Vygotski, who has suggested that for any learner there is the zone of proximal development just beyond current understanding, where more advanced ideas can be used with help (Vygotski, 1978). Scaffolding is an interactive process in which a teacher or facilitator assists learners to build a "structure" to contain and frame new information (Bull et al., 1999). Online scaffolding can be provided by teachers and peers. It might also be embedded in the information of separate web pages, interactive tutorials, help–pages or additional explanatory links.

THE CASE STUDY

The aim of the case study was to study the role of scaffolding in synchronous CSCL environment to identify effective facilitating methods for students' environmental decision–making process. The research questions were:

i) What is the influence of the facilitator on students' decision–making process?

ii) In what forms does the peer–scaffolding appear during a role–play activity?

iii) How does information–embedded scaffolding affect students' decisions in synchronous CSCL environment?

iv) What are the limiting factors of collaborative decision–making process in synchronous CSCL environments?

The study was conducted in April, 2000 in the text–based java chatroom of the Miksike Learning Environment (http://elutuba.ee). Sixteen 6th grade students from different Estonian schools participated in the online seminar and discussed what could be done with neglected dogs. The chat facilitator also served as a researcher.

The idea of the environmental role–play activity was to oppose the role–groups representing different environmental knowledge, attitudes and values to initiate the discussion for generating ideas, evaluating alternatives and implementing solutions. Supposedly this kind of role–play leads to the more competent environmental decisions compared with individual viewpoints.

Organizing the learning activity in synchronous CSCL environment both facilitator–guided and information–embedded scaffolding methods could be useful at different parts of the decision–making activity. Most models of the problem solving and decision–making include four phases (Huitt, 1992):

i) an Input phase in which problem is perceived and an attempts are made to understand the situation of the problem;

ii) a Processing phase in which alternatives are generated and evaluated and a solution is selected;

iii) an Output phase which includes planning for and implementing the solution;

iv) Review phase in which the solution is evaluated and modifications are made if necessary.

According to these phases of decision making a special learning protocol (Table 1) was generated for the chat–facilitator to guide the environmental decision–making process. The protocol was divided into facilitator– and peer-scaffolded parts, in order to investigate the role of facilitator – and peer-scaffolding during the collaborative role-play. Between the Input and Processing phase of the protocol the information – embedded scaffolding was tested. For this web materials about ethics and legislation were generated that supposedly had to attribute the roles of animal–protectors and town–inspectors to the decision–makers.

Designing the learning protocol the following aspects were taken into account.

During the Input phase, scaffolded by the facilitator, the individual decision–makers had to generate the mental models of the situation by recollecting their previous knowledge and memories. Supposedly the facilitator's questions, but also the attitudes and ideas of the peers could impel the process of forming the individual models.

In the Processing phase, when alternatives had to be generated and evaluated, the participants were to be actively involved in the discussion. Antagonistic roles could have helped them to debate and generate different alternative solutions. Through social interaction, the contradictions, inconsistencies and limitations of decision–makers' explanations could become available because they had to perceive their conceptualisations from different points of view (Vygotsky, 1978). According to Lindgren and Suter (1994) the argumentation at debate also increases the sensibility of the group members towards the problem and raises their interest to solve it. One possibility to attribute roles of the participants was to present additional web materials about different aspects of the problem before the Processing phase. This served as information–embedded scaffolding. The supplementary information could also act as the source of new ideas.

In our learning protocol the Processing phase was divided into two parts. The first part of it was designed to support free brainstorming and argumentation guided by peers themselves. By Osborn (1957) the method of brainstorming has a synergetic effect on the participants who will therefore be more productive and creative in teamwork than individuals. To think creatively they need to be stimulated by others. Brainstorming helps children to reveal and share the bank of knowledge they bring to the learning situation (Fisher, 1995). Two conditions are required to function creatively, psychological safety and psychological freedom (Rogers, 1961). Therefore, designing the learning protocol it was supposed that facilitators' interference into the idea–generating activity might suppress the process.

Constructivist teaching models suggest that the process of gaining new knowledge should be built up on the conceptions and ideas revealed by students. In our model the facilitator could use the alternative solutions and arguments generated by decision–makers at the first step of the Processing phase as the source of information to design the questions for the second part of the Processing phase during the activity. It has been stated that for novice problem–solvers the complicated problems should be divided into subtasks and solved separately (Eggen & Kauchak, 1995). Taking into account this recommendation the facilitator–guided part of the Processing–phase contained the subtopics of scientific knowledge, legislation and ethics that opened the different sides of the environmental problem for the decision–makers and helped them to consider all the important aspects to make a competent decision. At the end of the Processing phase the facilitator incited the participants to recite the best decisions and guided the decision–makers to the selection of the final decision.

The Output phase was also facilitator–scaffolded who tried to help students to work out the effective economical and ethical model for the asylum. The method of brainstorming was used for it.

Table 1. Design of the learning protocol for environmental decision–making in synchronous CSCL environment.

Phases of decision-making (Huitt, 1992)	Activities in the open-ended protocol	Facilitator's questions during the activity
Input phase: problem identification, problem definition	**Facilitator-scaffolded decision making**	
	I Introduction	
	II Attitude	Let's find out what you think of dogs. Do you have a dog? If not, then why? Are here any students who dislike or are afraid of dogs?
	III Causes of the problem	Why are there stray dogs at the streets? Are there more neglected dogs in the cities or in the countryside?
	IV Consequences of the problem	What bad consequences come from neglected dogs?
	V Individual solution	Please make your suggestions how to solve the problem of neglected dogs.
	information-embedded scaffolding	
	VI Attributing roles	Additional web pages about ethics and legislation were introduced to decision-makers.
Processing phase I: problem exploration and generating alternative solutions	**Peer-scaffolded decision making by role-play**	
	I Generating and evaluating alternatives	Facilitator initiated the discussion, but didn't interfere into the argumentation.
	II Collecting alternatives	Facilitator concluded the discussion when argumentation was calming down and all the alternative solutions were generated and evaluated by decision-makers.
Processing phase II: evaluation of solutions and step-by-step decision-making	**Facilitator-scaffolded step-by-step decision making**	
	I Step-by-step decision-making	Step-by-step facilitator is suggesting the alternative solutions generated by the decision-makers.
	- legal aspects	Should all the roaming dogs be caught? Who has the right to decide what dogs must be caught?
	- ethics	What must we do with the dogs trapped by a stray-dog catchers - to inject them against diseases and let them free or to inject them and let them sleep forever? Should the asylum for dogs be home for the stray dogs? Would you adopt a dog from the asylum for dogs? What must we do with spiteful dogs in dog's asylum?
	- environmental knowledge	Can we change the character of a spiteful dog? What would be better for the dog - freedom and roaming alone or life inside the house or in the back yard? Can we let dogs from the asylum free into forests?
	II Forming the decision	Decision-makers had to choose and vote for the best decision.
Output phase:	**Facilitator-scaffolded implementation of the decision**	
problem integration and implementing the solution	I Implementing the solution - economy	How to improve dogs' life in asylums? What can each of you do to help neglected dogs in asylums? How to make the dogs' asylums more popular? How can the asylum itself earn extra money for the neglected dogs? How should the asylum be funded?

FINDINGS

The facilitation process was evaluated by analyzing log–files of the role–play and the impressions of the participants and the facilitator.

The first step was the content analysis of the log-file to distinguish the types of students' responses to the questions of the facilitator. It was supposed that students' responses reveal their thinking processes during the decision–making activity. The following types of responses were found: i) presenting arguments (without or with justification and reasoning); ii) evaluating arguments (uncertainty, approving/disapproving arguments, initiating discussion); iii) making decisions (with or without justification and reasoning); and iv) social talk (irrelevant talk).

Secondly the log file of the role–play was analysed according to the activities presented in the learning-protocol (Table 1) to find out the role of different types of responses during the peer–scaffolded and facilitator–scaffolded phases of the activity. To the analysis all the students' responses in a certain phase were counted and the percentage of different types of responses was found (Table 2).

Table 2. Types of students' responses during the decision–making activity.

Phases of the decision-making activity	Presenting arguments	Evaluating arguments	Making decisions	Social talk	Total number of responses
Input phase	65 %	22 %	11 %	2 %	156
Processing phase I	23 %	33 %	27 %	17 %	111
Processing phase II	13 %	39 %	41 %	7 %	260
Output phase	17 %	36 %	39 %	6 %	169

It was supposed that the types of responses in presenting and evaluating arguments and making decisions that reveal the activities of the decision–making process had to dominate in the subsequent phases of the activity. This presumption was confirmed by the data (Table 2) which revealed the effectiveness of the learning protocol (Table 1) in guiding the decision–making process.

The prevalence of the argument presenting type of responses during the facilitator–scaffolded Input phase could be explained as the indicator of active forming of the mental model caused by the facilitators' questions but also by companions' arguments. The discussion with peers helped to formulate arguments and therefore affected on the formation process of the mental model. It can be illustrated by the following example:

Facilitator: Are there more neglected dogs in the cities or in the countryside?

Child 1: There are more in the cities.

Child 2: There are more neglected dogs in the cities, because there are more people.

Child 1: Right!

Child 3: The neglected dogs will frighten away wild animals.

Child 1: No they wouldn't.

Child 1: Wild animals will scare neglected dogs.

Often new ideas arose from the statements of other students. It appeared to be one form of peer scaffolding during the discussion:

Facilitator: What should be done with stray dogs?

Child 1: They should be taken to the sanctuary, because then people can come and adopt them.

Child 2: I agree. We should make some new sanctuaries.

In both Processing phases (I & II) the evaluation of arguments created by other students and the decision–presenting exceeded other types of responses. It revealed the effectiveness of the phase. Although the analysis of the log fail showed that students' formulated most of the decisions with limited justification and evaluated decisions mainly by approving or disapproving them.

In order to assess the rate of students' interaction with each other in the different phases of the decision–making activity the number of responses revealed during the discussion between peers was compared with the total number of responses of the phase.

Table 3. Peer–discussions during the decision–making activity.

Phases of the decision-making activity	Peer-discussions per phase	The average number of responses in the peer-discussion
Input phase	31 %	3
Processing phase I	76 %	6
Processing phase II	23 %	3-4
Output phase	12 %	2-3

Comparing the facilitator–scaffolded Processing phase II with the peer–scaffolded Processing phase I (Table 2) we can presume that in free atmosphere the decision–makers could find out the contradictions and limitations of their decisions more precisely. The phase scaffolded by peers had also bigger ratio of students' interaction with each other (Table 3), which can be explained by the absence of facilitator's dominating role during the activity. Text–analysis of the log file also showed that the higher rate of social talk in the peer–scaffolded phase could not be explained with the lower task orientation but it indicated students' active participation and task–orientated argumentation.

The comparison of decisions made in Input and Processing phases (I & II) of the activity showed that during the peer–scaffolded Processing phase I the biggest number of different alternative decisions was formulated (Table 4).

Although students could work effectively by themselves during the Processing phase, they couldn't draw conclusions and consider the alternatives generated in their final decision. Therefore, the Processing phase must be concluded by the facilitator, in order to help the decision–makers to evaluate different alternatives and to select the final solution. According to the constructivist paradigm of learning the facilitator's flexibility and openness would be of great importance when designing the questions for the evaluation part of the learning protocol. The facilitator has to consider all the alternatives generated during the peer–scaffolded phase according to the learning protocol and present them to the decision–makers in the form of questions promoting higher order thinking.

Table 4. Types of decisions in Input and Processing phases.

What should we do with stray dogs?		
Input phase	Processing phase I	Processing phase II
*they must be taken to the asylum for stray dogs[1] *we should find new masters for them	*they must be taken to the asylum for stray dogs[1] *we should find new masters for them	*they must be taken to the asylum for stray dogs[1] *we should find new masters for them
*we must catch them *they should be supported with money *we should try to heel them	*masters who let their dogs to wander should be punished *masters should be informed how to avoid dog's pregnancy *the dogs must be registrated with signs * the dogs must be fed properly *the dogs should be taught to behave well *the dogs shouldn't be kept freely	*dogs with the registration-sign should be returned to the masters
*we must create more asylums for dogs *people shouldn't take dogs if they don't take care of them	*we must create more asylums for dogs *people shouldn't take dogs if they don't take care of them	
	*these dogs must be taken under the nature protection *these dogs should be killed	*these dogs must be taken under the nature protection *these dogs should be killed
*people must take good care of dogs *the neglected dogs should be given to households in the country		*people must take good care of dogs *the neglected dogs should be given to households in the country

[1] Final decision in Processing phase II

In the Output phase, where the solution should be implemented, all types of task–orientated responses were represented. This showed that in the Output phase the decision–makers were generating the model that would help them to implement the decision by representing and evaluating different arguments and making alternative decisions.

During the activity the participants often expressed their dislike to social talk as a misleading factor of the activity that helped to keep the task–orientation of the conversation which can also be explained as an evidence of peer–scaffolding.

Information–embedded scaffolding was tested in the phase of attributing roles to the decision–makers with different additional materials. The students had to follow the links to the web pages to read about legislation and ethics concerning neglected dogs. This helped them to become acquainted with the roles of town–inspectors and animal–protectors. Some technical difficulties also appeared, because the students had to view supplementary web pages in different windows and it was confusing them. At the beginning of the peer–discussion both roles were followed, but afterwards the role of the animal–protector that corresponded with the attitudes of most students started to dominate. The different roles helped to initiate argumentation between the participants that promoted the generation of different alternative solutions.

The role of supplementary materials as the source of ideas was also proved. The analysis showed that several discussions were held on the topics drawn from the pages of legislation and ethics, although the legislation facts had stronger influence on students' decisions (Table 4). The role of supplementary materials as the source of ideas can be illustrated by the following example:

Child1: The dogs shouldn't run freely. (legislation)

Child 2: We should train them to behave well.

Child 3: The dogs are living organisms like us. (ethics)

Child 4: They want to live. (ethics)

Child 5: The dogs must have shorter leashes. (legislation)

Child 2: Right.

The limiting activity of the decision–making process in synchronous CSCL environment appeared to be the evaluation of alternatives and proposing decisions during the peer–scaffolded Processing phase. The size of the role-group also had an influence on the activity, because the participants couldn't follow all the arguments and react properly during a fast discussion.

The case study helped to have an inside look at the processes happening during the decision–making activity in synchronous environment. It provides the educators with useful information in planning the scaffolding–methods of decision–making activities in synchronous CSCL environments.

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Ion-Selective Electrode Determination of Potassium Ion Concentration of Various Beverages including Several Potassium-Depleted Juices

Akira Yamasaki, Japanese Red Cross College of Nursing, Japan
KGH01640@nifty.ne.jp
Akiko Furuhashi, Aoyama-Gakuin University, Japan

SYNOPSIS

Electrochemical determination of potassium ion concentration was carried out for various beverages to seek the appropriate ones for the patients who have severe renal failures. Several kinds of potassium–depleted juices have been prepared and compared with those of ordinary ones.

INTRODUCTION

It has been a great problem for the patients who have severe renal diseases to limit the intake of potassium from foods and drinks. They are usually obliged to decrease the potassium intake in diets, mainly vegetables, fruits or beverages as low as possible. To facilitate the function of nephron of these pre-dialysis patients, it is recommend increasing the amount of intake of the water to remove the waste products as urine. However, the existence of potassium ion,Å@ one of most common and powerful diuretics, are strictly limited because of the disability of renal functions. The increase of blood potassium concentration is occasionally fatal.

The determination of potassium concentration is, therefore, very important to suggest the appropriate beverage for each patient separately. Of course, there are various modern instrumental spectroscopic determination techniques such as colorimetry, flame spectrometry, inductively coupled plasma(ICP) or atomic absorption spectroscopy (AAS). It is also favorable to measure simply everywhere outside of modern laboratories mostly for the monitoring of daily foods and drinks.

The simple determination of potassium concentration has been carried out in small–scale samples using potassium ion-selective electrodes, and portable membrane electrode instruments. These simple measurements have enabled us to classify various beverages from many different origins.

EXPERIMENTAL

Determination of Potassium Ion Concentration: Orion Ion-Meter Model 250A was used for the potential measurement with potassium ion selective electrode Model 93–19. Five milliliters of samples were mixed with an equal volume of 0.2 mol/L sodium chloride solution (for constant ionic strength). Calibration curves were drawn with several standard potassium chloride solutions. In the case of low potassium containing samples, the standard–addition technique was also used for accurate determination.

A Horiba Model C–131 Compact Ion Meter was also used for rapid estimation of potassium ion concentration in micro scale (only one drop of sample solution is sufficient for measurement by this apparatus). Although the deviation might be possible because the reading of this ion meter is of ppm scale, the coarse and rapid measurements are possible everywhere even outside of modern chemical laboratories.

Beverage Samples: Commercially available fruit-juices (orange, lemon, grapefruit, mandarin orange, apple, grape, pineapple etc.,) and vegetable juices (carrot, tomato etc.,) were taken for the potassium ion determination. These canned or bottled juices were obtained from the trustable food shops around our college. Coffee and tea samples were brewed by the ordinary procedure. Several commercially available canned coffee and tea samples were also tested for reference.

There are small numbers of potassium–depleted drinks are also available commercially. We have fortunately obtained several kinds of newly prepared potassium-depleted beveragesÅ@[Kinoshita 1998] and the potassium concentration was determined for these newly prepared and commercial samples.

RESULTS AND DISCUSSION

The potassium concentration range of various beveragesÅ@is shown in the following table.

Table 1. Potassium Concentration Range of Beverages

	Potassium Ion Concentration
Vegetable juices	1500–2700 ppm
Orange juice	1500–1900 ppm
Grapefruit juice	1300–1400 ppm
Mandarin Orange juice	1600–1800 ppm
Apple Juice	800–1000 ppm
Coffee	400–650 ppm
Bottled Coffee	500–600 ppm
Roasted Japanese Tea	200–400 ppm
Green Tea	80–120 ppm
Chinese Tea (Oolong Tea)	80–160 ppm
Black Te	80–120 ppm

Most of juice samples contain about 0.1—0.2% (1000–2000ppm) potassium ions, which are consistent with literature data [Barnes, 1997, Wang, 1992]. This relatively higher concentration seems to be occasionally perilous for the patients of renal failure. The depletion of potassium from these juices was tried by Kinoshita and his groups by ion–exchange resin. The details are shown later.

Some samples of commercially available "low–potassium drinks" (from TERUMO Co.) have been also examined by the same technique. Typical results are shown below:

Sample A(Terumeal mini coffee taste)	165 ppm
Sample B(Terumeal mini fruits taste)	189 ppm

These drinks showed relatively low potassium concentration, but seem to be not necessarily sufficient for the patients of the severe renal diseases. We should develop the much more effective potassium depletion processes which are appropriate to these higher potassium concentration.

The potassium concentration of laboratory–prepared potassium–removed apple and fruits juices are shown in the following (These are processed with cation exchange resin) compared with commercially available ones prepared similar technique.

Sample C(apple juice K^+ depleted)	35 ppm
Sample D(vegetable mixed juice K^+ depleted)	110 ppm
Sample E(apple juice, Meiji Seika Low Potassium Drink)	50 ppm
Sample F(vegetable juice, Meiji Seika Low Potassium Drink)	120 ppm

In Japan, the population of relatively old–aged peoples has been developed gradually in these decades continuously as the result of the progress of modern medicine and hygiene. Among these gerontal population, the patients of severe renal failures also becomes serious problems in these days. Such peoples should be controlled for their daily diets including drinks and beverages which contain occasionally non–negligible amount of potassium ion in the pre–dialysis stage already. The strict limitations of potassium intake are a great problem for such patients from foods and drinks. To facilitate the function of nephron of these pre–dialysis patients, it is recommend increasing the amount of intake of the water to remove the waste products as urine. However, the existence of potassium ion, one of most common and powerful diuretics, is strictly limited because of the disability of renal functions. Such a dilemma should be got around for the sake of the improvement of QOL(quality of life) for these chronical patients. They have a eager tendency to take unadvisable foods or drinks in spite of the direction or restriction by doctors.

The depletion of potassium ion from the several kind of beverages has been already carried out after cation–exchange resin method [Kinoshita, Komai, Hirashima, 2001], and some products are distributed from Meiji Seika Co. (One of the famous food industries in Japan) as the Healthy Foods(Patent Pending) as above. These potassium–depleted vegetable juices have been examined their efficacy for the pre–dialysis patients who have renal deficiencies of different grades.

Clinical investigations have been made with these potassium-depleted juices for chronic renal failure patients [Issoh, Matumoto, Kinoshita 1999] and observed the decrease of potassium concentration in bloods thoroughly.

POTASSIUM DEPLETION TECHNIQUE FOR SEVERAL BEVERAGES

Ion–exchange resin technique: The potassium in vegetable juice or apple juice has been successfully removed by hydrogen–form cation exchange resin [Kinoshita, Komai, Hirashima 1998]. After the potassium ion adsorption by resin, the resultant acid is neutralized with calcium carbonate powder.

However, this process cannot be applied for caffeine–containing beverages because the cationic forms of caffeine are also absorbed more strongly than potassium.

Inorganic cation exchanger—Zeolite technique: Commercially available zeolites of sodium aluminosilicate type (such as Molecular Sieves 4A) column can be used efficiently for the potassium removal from various teas (including Chinese tea (Oolong-tea), Roasted Japanese tea (Ho-ji cha) etc.). These zeolites have cavities of a definite sizes, which cannot include the large cations such as caffeine. Therefore, it seems suitable to remove the potassium ion from beverages containing caffeine such as teas or coffee. The 96–98 percent removal of potassium from chinese(Oolong) tea, roasted tea or green tea was possible without the loss of caffeine through simple zeolite column by potassium–sodium ion exchange in zeolites.

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Decision-making Promotion via an Interdisciplinary Curricular Module in Environmental Education

Michal Gross and Uri Zoller, University of Haifa at Oranim, Israel
uriz@research.haifa.ac.il

Key words: Decision-making, STES Curricular Module, HOCS

Decision-making is considered to be essential for any meaningful action with respect to environmental or inter-related science-technology-environment-society (STES) issues. "The White gold in Deep Soil - Groundwater" is an interdisciplinary modular curriculum unit which was developed by the Science, Technology and Environment in Modern Society (STEMS) project team at our university (*Environ. Educ. Res.*, 1999). The teachers who implemented this unit in their classroom were members of the unit's team development.

Within the study of this unit the students deal systematically with local and global scientific-technological and socio-economical-political problems associated with, or related to, groundwater, and are exposed to real life decision-making situations; e.g., where is it expedient to dig and pump water? Who should manage the country's water resources? How should the limited available water be shared between the different sectors? To answer these questions, the students have to ask relevant questions; to select and use the relevant information; to assess the benefits, trade-offs and consequences of each chosen alternative; and to apply societal values, value judgment and political considerations in their decisions.

The focus and objective of this study were, therefore, the assessment of the effect of this curricular unit on the decision-making capability of high school students. The research population consisted of 97 students of about 15 years old, from five different heterogeneous 10th grade classes in two different schools: Two classes served as the experimental ('treated') group and one as the control in a rural high school. One experimental and one control class in a large public high school in a small developing town. The students in the experimental class learned the interdisciplinary modular unit: "The White Gold in Deep Soil-Groundwater" for 3 hours per week for 7 months. At the same time, students in the control classes studied a conventional 10th grade Physics course. To assess changes (if any), a multidimensional HOCS Evaluation Questionnaire (HEQ) was used (i.e.,— 1997). The HEQ was administered twice 7 months apart (pre- post test). The results were statistically examined including analysis of variance via ANOVA test.

The aim of each question in the HEQ questionnaire was to evaluate the skill requisite in the decision-making process, such as the ability to ask relevant questions, selection of relevant and significant criteria for making a decision; and application societal values and political considerations in the process.

A comparison between the pre- and post-test (table 1) reveals an increase in the mean scores of students in 3 of the 4 research classes. Although the differences are not statistically significant, they do indicate a trend. Such results may either reflect the actual effect of the module (as it is, indeed, indicated in the classes of school Y) or, perhaps, this is a consequence of the students' natural aging/maturation (as it is apparent in the classes of school M). Yet, in comparing the control to the experimental classes, one can see, that there is a significant difference ($p<0.05$) between these classes in one of the schools (Y). These results indicate that learning this module may improve the students' ability of asking questions. In the other school (M), in both classes, there was an increase in the mean scores due, most probably, to different reasons (as will be discussed in the full paper). Over all, the results indicated that in the experimental classes the students did improve their ability to ask high-order questions.

Figures 1 and 2 (will be given in the full paper) clearly demonstrate that in both experimental and control classes the boys prefer to select a particular alternative while the girls preferred the "no preference" responses. Possible interpretation of this finding is that boys have a better knowledge concerning the particular specific subject whereas the girls are much more careful (reluctant) in making selections and need more information for making a decision. The real question here is – why? Is it because the tendency to make a decision only after becoming sure that indeed the chosen alternative is the right one? Or, did the girls need more time and information? Or, alternatively, is this a way of avoiding the taking of responsibility, or lack in self-confidence? Further research is needed for responding (theoretically) to these questions.

The sum of all categories in Table 3 (will be given in the full paper) provides a "first approximation" idea about the students' decision-making profile. A low decision-making profile is thus emerging. The increase in the students' decision-making score profile is, apparently, due to the increase of the students' ability to ask HOCS questions. This is not surprising and should be taken into consideration in the training of new STES teachers.

During the 7-month period (between the pre- and post-test), the decision-making profiles of both experimental and control classes were improved, meaning that the students' maturation plays an important role in this respect. The question which still remained unanswered is whether, or, to what extent the recorded increase in the decision-making capability of the experimental students can be solely related to the teaching of the STES-oriented module.

It is very difficult to make a decision, particularly as far as real problems are concerned. Exposing the students to such decision-making problem-solving situations involving science and technology as well as sociological, economical and political aspects, merely has the potential of increasing their ability to make rational decisions in the future. It seems that the development of HOCS-oriented decision-making is a longitudinal and multidimensional process with no "short cuts".

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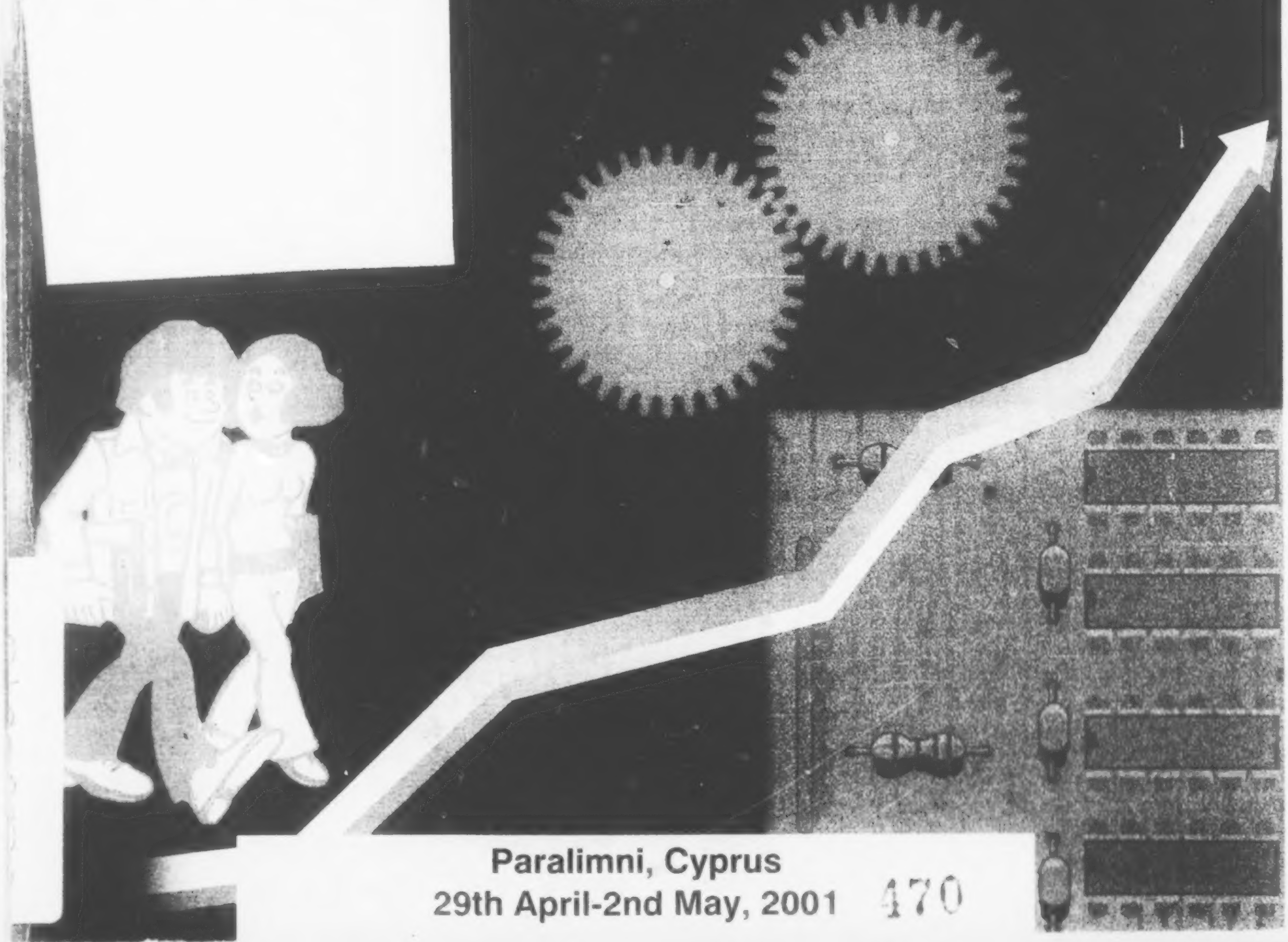
Ist IOSTE Symposium in Southern Europe

SCIENCE AND TECHNOLOGY EDUCATION:
Preparing Future Citizens

Volume II



Paralimni, Cyprus
29th April-2nd May, 2001

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VOLUME II

SECTION 1:

Action Research Involving Classroom Related Studies and Professional Development Studies

SECTION 2:

Resources Supporting Teaching, Including Locally Produced Equipment, Visualization Ideas Using New Technologies

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International Organization of
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George Kalkanis, Science, Technology, and Environment Laboratory of the Pedagogical Department, Primary Education, University of Athens, Greece

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Preface

When you embark on a journey, wish that the road to your destination would be adventurous, full of experiences and knowledge for you to gain. Wish that in your travels you will find others to share these experiences with, and together to construct ways about how to successfully find the way to your Ithaki - just like Ulysses did with his men, when for more than 20 years he was desperately trying to return to its hometown Ithaki.

As some of you might have realized, I just paraphrased some verses from the poem Ithaki of the Greek poet Constantinos Kavafis, because of its relevance to our case. For Ulysses, the objective was to reach his homeland Ithaki; for us, it was to organize this conference and invite all of you to come to the hospitable town of Paralimni, Cyprus. You responded to our invitation and you came here not just as visitors but also as concerned science and technology educators striving to promote the objectives of our community. At a time when much attention is being placed on ***'Education for All'*** *and the role played by science and technology education in providing a relevant education for all future citizens, we unanimously agreed that it was appropriate to draw attention to the role of science and technology education.* ***"SCIENCE AND TECHNOLOGY EDUCATION: Preparing future citizens"*** *was announced as the theme of the* ***"1st IOSTE Symposium in Southern Europe".***

As we all know, there has been a strong tradition of rewarding excellence in science and technology, even at the expense of relevance for all, but for the new millennium there is a need to find ways to combine the two. How is it possible to provide a strong science and technology background for those wishing to pursue these subjects to a higher level and yet, at the same time, provide an appropriate and rewarding science and technology experience for all students. In other words, instead of portraying science and technology as subject matters where success is largely measured by memorization of facts, the efforts are directed towards popularizing science. The purpose is to increase public awareness for future citizens by encouraging student participation in problem solving and decision-making activities. These were the main concerns of our IOSTE Symposium.

We really appreciate your willingness to join us here and share your research evidence, your ideas, and concerns with us. Despite the long and difficult process of organizing the ***"1st IOSTE Symposium in Southern Europe",*** *we conclude with the verses of the poem Ithaki wishing a long and difficult road to our destination, because the experience was invaluable and rewarding. We worked together to construct educational visions, goals, plans, and directives. We used our minds together to make sense, decide, plan, and take action. But gradually what became most important to us was* *interacting and collaborating with you. During this process, we engaged in conversations, shared insights, and established links between your interests and our interests. A community of practice started to form.*

We aim with this conference to start a dialogue about our field of study and sustain this dialogue through collaboration that will continue well after this conference ends. We have been suffering from feelings of isolation and it is only by fighting these feelings of isolation that we will be able to advance our thinking and practices. We also strive with this conference to bring scientists, researchers, and practitioners together to form partnerships and inform one another for the purpose of better educating our children.

The theme of our conference is how to prepare our students to become science-and-technology literate. We live in an age of continuous scientific and technological advancement. How should we educate our students to survive in a rapidly changing world? How should we make education relevant to real life? Science is life itself and there is a need to design powerful learning environments in which learners experience the discipline of science as relevant to their everyday life. In these environments, the learner is no longer considered an empty vessel or a passive recipient of information that someone else delivers. The learner explores, constructs, and problem-solves within a context, and actively communicates and interacts with the teacher and other learners.

In the second volume of the proceedings, members from our community of practice share with you their insights about **"Action Research, involving classroom related studies and professional development studies",** *while others contribute their understandings related to* **"Resources supporting teaching, including locally produced equipment, visualization ideas using new technologies".** *The information gathered from research activity can successfully guide us on how to employ resources, equipment, and new technologies to reshape classroom environments for promoting literacy in science and technology.*

Cordially,

NValanides

Dr Nicos Valanides
Chair of the Organizing Committee

Action Research, Involving Classroom Related Studies and Professional Development Studies

Why Action Research?

Avi Hofstein, The Weizmann Institute of Science
nthofstn@wisemail.weizmann.ac.il

The 60s and the 70s were the 'golden-age' of reform in curriculum development in science and mathematics. In contrast, the current reform is characterized by the development of new science curricula and attention to the professionalization of science teachers. This new focus is based on a lesson learned from the previous intensive and comprehensive efforts with curriculum development, where it became apparent that a good curriculum is necessary but is by no means sufficient itself, since teachers rarely use curriculum materials as intended by their developers (Romberg & Pitman, 1990; Yager, 1992). Similarly, Ganiel (1995) claimed that the availability of good learning materials does not ensure good teaching or successful learning. Most importantly teachers need help in the process of implementing the newly developed material. It is suggested that this goal can only be attained by providing teachers with a supportive, long-term environment that will enhance professional development (Loucks-Horsley, Bybee & Wild, 1996).

Teaching science in the classroom, however, requires much more than a straightforward implementation of a curriculum. It involves attention to classroom discourse, and to overt and covert messages conveyed when asking students questions and conducting discussions, as well as mutual activities. Consequently, in addition to knowledge content and curriculum knowledge, the teacher needs quite sophisticated knowledge of science teaching and learning theory.

The 'new' content, pedagogy, assessment, and professional development standards published in the USA (National Research Council (NRC, 1996) specify the scientific content that all students should know and be able to utilize. The teaching and professional development standards define the knowledge, skills, and experience that teachers must have if they are to engage in teaching science. In regard to the professional development, Bybee (1995) wrote that

> The Professional Development Standards describe the criteria for the preparation and ongoing opportunities that teachers must have to gain and maintain the knowledge base and skills, and to provide the learning opportunities for students that the teaching standards define (p. 32).

The key question in professional development planning is to decide which strategy to adopt in order to attain the goals of professional development. Note that in general, professional development plans consist of a combination of strategies to form a unique design (Loucks-Horsley, Hewson, Love & Stiles, 1998).

One such strategy for professional development is action research. Action research means that teachers research their own practice of teaching. It is an inquiry into their teaching and their students' learning in their own classroom (Feldman & Minstrel, 2000). According to Feldman (1996), the primary goal of action research is not to generate new knowledge whether more local or universal but rather, to improve practice. Lewis and Munn (1987) indicated three main reasons for conducting teacher-based research: (1) to try to find out what is actually going on, (2) to monitor and thus formatively influence the direction of new developments and (3) to evaluate what is already taking place. According to Feldman & Minstrel (2000), the main reason for action research to become an integral part of the implementation process of curricula is that it reduces the time lag between the generation of new knowledge and its application in the classroom.

In her book "Designing Professional Development for Teachers of Science and Mathematics" Loucks-Horsley et al , (1998) wrote that

> Action research has evolved in the education community into an ongoing process of systematic study in which teachers examine their own teaching and students' learning through descriptive reporting, purposeful conversation, collegial sharing and critical reflection for the purpose of improving classroom practice (p.95)

In the past, many of the initiatives and ideas developed by teachers were neglected due to the dichotomy that existed in the educational system in which research, development, implementation, and evaluation were conducted by academic institutions. Science teachers usually served as a vehicle for collecting data and implementing the learning materials developed by others in their own classes.

In recent years we have observed an important change in the way we perceive the role of the teachers in the various components of the curricular process. The two main areas in which teachers are involved are (1) the teacher as a developer of learning materials, and (2) the teacher as a researcher.

With regard to the teacher as a curriculum developer, Ben-Peretz (1990) claimed that teachers may function as creators of their own curricula weather through involvement in the process called "teacher-based curriculum development" or as "participants in centralized curriculum efforts." This is fondly called 'bottom-up' as opposed to the 'top-down' process. According to Ben-Peretz, teachers come with creative ideas about teaching in general and pedagogy in particular. They are also familiar with their students' needs and abilities. Thus, with proper training teachers, could serve as school-based curriculum developers and researchers (Feldman & Minstrel, 2000; Hofstein, Mamlok & Carmeli, 1997).

These two functions are derived from the idea that teachers are responsible for the progress and well being of the students in their classes. Thus, their professional obligation is to review periodically the nature and effectiveness of their teaching as well as to improve the quality of their management, the pedagogy, the learning materials and the decision making process.

In recent years action research has been viewed as a one of the major forms of professional development utilized in order to attain the new content, pedagogical and organizational science standards that have been advocated in many countries around the world (NRC, 1996; Tomorrow, 1992).

As before mentioned, the strength of action research as a professional development strategy is that teachers either define the research questions or contribute to defining them in a meaningful way (Loucks-Horsley et al. 1998). The use of action research as a strategy for professional development is based on the following assumptions (Loucks-Horsley et al. 1998, p.97):

- Teachers are intelligent, inquiring individuals with important expertise and experiences that are central to the improvement of education practice.
- By contributing to or formulating their own questions and by collecting data to answer these questions, teachers grow professionally.
- Teachers are motivated to use more effective practices when they are continuously investigating the results of their action in the classroom.

In order for action research to be an effective means for helping teachers to reflect on their practice, we must provide them with the opportunities to engage in life-long professional development. These opportunities will provide them with an environment of support, collegiality, and collaboration with professional researchers and other teachers who teach the same or related subjects, an environment that encourages reflection on their classroom practice and the results of their research efforts. According to Holly (1991), collaboration is now seen as a major form of professional development. A major vehicle for this collaborative inquiry is conducted by professionals acting as reflective practitioners.

Typically, teachers who are inexperienced in action research need support and training regarding its methodology, procedures and activities. This includes designing tools, collecting data and analyzing and interpreting the results, and finally applying the findings in the science classroom. Engaging in professional development provides the teachers with an opportunity to share the results of their classroom research and related pedagogical activities with their fellow teachers who will provide them with feedback and other ideas.

It was also suggested that long-term professional development activities could create a clearing-house for pedagogical ideas that were derived from the results of the action research conducted by the participants in a professional development workshop.

I have decided to elaborate on the potential of action research by describing three case studies in which action research was used as a key strategy for professional development.

CASE STUDIES DESCRIBING THE PRACTICE OF ACTION RESEARCH

Case Study 1: Action Research as a Form of Development of Leadership among Science Teachers

The implementation of new content and pedagogical standards in science education necessitates intensive, life-long professional development of science teachers. Israel, which is currently in the process of reforming school science and mathematics (Tomorrow, 98), constructed a continuous, life-long framework for such professional development. This framework includes the development of science teacher leaders who are expected to support the attainment of the goals of reform in science education in the country.

A two-year-long workshop aimed at developing leadership among chemistry teachers was conducted. The general goal of this workshop was to develop leadership whereby the teachers will support contemporary reform in science education in general, and the way chemistry is taught in particular. Altogether, the workshop consisted of 450 hours over a period of two years. A total of 38 chemistry teachers participated in two rounds of the program.

In planning professional development for leaders (leading teachers) one has to include all the factors that will characterize the more holistic, long-term professional development of science teachers, and also those that clearly identify the roles of the leaders that we wanted to train. According to Locks-Horsley et al., (1998), we usually expect leading teachers to be involved in

- ☐ Teachers' professional development: to act as trainers and guides, and as coaches and facilitators of various support groups, and
- ☐ School-based leadership: curriculum development, providing leadership in instruction and assessment, and in implementing science curricula in their schools and/or district.

Naturally these activities also include the initiatives in conducting action research in the various science classes in the school.

The philosophy central to the course that was conducted at the National Center for Chemistry Teachers is that in recent years there has been a major change in our perception of the content and pedagogy of chemistry teaching and learning. To reform the content and pedagogy of chemistry teaching, there is a need to educate leaders who will eventually serve as agents for change. In order to become leader, the chemistry teachers have to undergo development in the following interrelated fields and dimensions:

- ☐ The new scope of high school chemistry (content knowledge) in which teachers act as a Learner of subject matter and also undergo experiences similar to their own students, with the knowledge of how students construct their knowledge in their mind.

- ☐ Improvement of the pedagogy of high school chemistry (pedagogical content knowledge) in which teachers act as Teachers in their classroom.
- ☐ The teacher as a Leader who serves as an agent for change and supporter of reform.

In the learning-of-content phase of the professional development, the teachers behaved as Learners. In other words, they were involved in learning of the subject matter the same way and using the same methods as the students. In the program we adopted the constructivist approach in which teachers were involved in activities that enabled them to integrate the chemistry subject matter with information from the literature regarding how students learn and how they construct their knowledge (Bell & Gilbert, 1994).

This approach is supported by the review on professional development conducted by Kennedy (1998) who found that professional development programs in which teachers investigate how students learn the subject matter are most successful in improving students' achievement, as well as improving the teachers' ability to learn a specific subject matter.

During this phase of professional development the teachers were provided with many opportunities to engage in action research mainly in the area of the cognitive aspects of learning chemistry, i.e. misconceptions and learning difficulties. More specifically, teachers were trained in diagnostic evaluation methods. The results were discussed at the workshop and the teachers were asked to provide explanations and to identify the origin of the cognitive obstacles. Finally, they were asked to develop remedies to the misconceptions, to try them in their classroom and to determine whether they managed to overcome the observed learning difficulties. The development of pedagogical remedies is highly related to what Shulman (1986) defines as 'pedagogical content knowledge' (PCK), as follows

> It represents the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations – in a word, the ways of representing and formulating the subject that make it comprehensible to others (p. 9).

The main goal of this dimension involving the participating teachers is to improve the ways and methods that chemistry is taught and as a result, to improve the classroom and laboratory learning environment (Tobin, Capie, & Bettencourt, 1988).In this phase of the course the teachers act as Teachers in their own classrooms.

Hofstein and Walberg (1995) suggested that instructional techniques in science should be matched with the learners' characteristics and needs in order to maximize the effectiveness of the teaching and learning processes and also to increase student motivation. Hofstein and Kempa (1985), who postulated that some relationships exist between students' motivational traits (characteristics) and their preferences for particular teaching and learning strategies, also supported this idea.

Clearly, in practice, it is difficult to respond to each student's needs and motivational characteristics, but much can be achieved if teachers use a wide repertoire of instructional strategies, instead of limiting themselves to only one or two. To do so requires not only skills and knowledge in a variety of teaching methods, but also leadership (managerial) competence to implement them in the school, the region, and in the whole educational system. This represents a major challenge to professional development for teachers and educators.

The participating teachers obtained first-hand experience with a variety of instructional methods. The workshop provided them with opportunities to try new instructional techniques in their own classes and to assess students' achievements and perceptions (i.e. interests and attitudes) as a result of using a particular technique or approach. Participating in the program provided them with opportunities to reflect on their work and obtain immediate feedback on their experiences from their peers.

The following are a few examples of action research topics in which the participating teachers were involved:

- The influence of alternative assessment techniques on the attitude of students toward learning chemistry.
- Applying different teaching strategies to the learning of the concept pressure in the context of high school chemistry.
- In teaching chemistry, the effectiveness of using the inquiry method in the laboratory on students' attitudes towards and interest in high school chemistry.
- The effectiveness of using the Internet for understanding of the concept 'solubility of ionic compounds.'

SUMMARY

Based on research on professional development as well as various changes in schools, it is clear that leadership is required for professional development experiences to be turned into actual changes in teaching and learning (Tobin & Jakubovski, 1990; Fullan, 1991; Bybee, 1993). The central goal of the course was to develop leadership among chemistry teachers who will foster such changes in chemistry education.

The leadership program was the vehicle for the participating teachers to use an action research cycle of planning, acting, observing, and reflecting. The national center linked them with out-of-school sources of knowledge regarding the methodology of action research and and its applications. Moreover, the teachers acting as action researchers usually worked together on the various components of the project. Loucks-Horsley et al. (1998) suggested that the collaborative nature of interactions (provided in the professional development workshop) allows for mutual understanding and democratic decision-making and requires the participants to act in a collegial manner.

Case Study 2: Changing the pedagogy of high school physics: the implementation of new instructional methods in the physics classroom.

A project titled "From the Center to the Classroom" is sponsored by the National center for Physics Teachers. The main goal of this project is to induce changes in the way physics is taught in the upper level of secondary school (grades 10–12).

The project involved thirty teachers who participated in a longitudinal workshop in three regional centers. These teachers were trained to use specific instructional strategies in teaching high school physics. classroom. The three strategies were aimed at overcoming problems that originate from learning difficulties and misconceptions. Action research conducted by the teachers was used in order to gain insight regarding the students' ability to better understand a certain concepts and as a result to follow changes that the students underwent regarding their attitude toward and interest in the specific concepts as a result of using a certain learning strategy.

The three strategies are as follows:

- The 1st strategy is based on a model developed by McDermott (1998), who conducted a survey in which she found that a big discrepancy exists in physics between what is taught and what is actually learned. She claimed that in order for conceptual change to occur active learning is needed. Instructional materials were developed based evidence of research conducted over a period of several years. The development of these instructional materials is follows:
    1. Conducting systematic investigations of students' understanding.
    2. Applying the results in the development of instructional techniques such as learning sheets.
    3. Designing, testing, modifying and revising instructional materials in a continuous cycle.
- The 2nd strategy is based on the use of diagnostic questionnaires that were developed through the years in order to identify learning difficulties and alternative conceptions in physics.
- The 3rd strategy implemented used the "peer instruction' technique originally developed by Mazor (1997). The basic goal of this approach is to exploit student interaction during lectures and focus students' attention on underlying concepts. This is implemented by giving the students short presentations on key points immediately followed by short conceptual questions on the subject being discussed. Mazor, (1997) suggested that this approach forces students to think through the arguments being developed and it provides them (and their teachers) with a way to assess their understanding of the concept.

The teachers with the support and guidance of tutors from the national and regional teachers' centers are developing methods to follow the changes that their students undergo. These include attitude questionnaires; achievement tests for diagnostic purposes, and tools to observe the learning of physics in the classroom. The results of the 'action research' are discussed in the centers and are used for changes and further development of instructional materials.

Case Study 3: Varying students' assessment methods in order to improve the pedagogy of high school chemistry.

As mentioned in the 1st case study one of the key issues regarding the teaching of science is to implement new and varied instructional techniques by teachers in their science classroom. The idea is that instructional techniques in science should be matched with the individual learner's characteristics and needs, in order to maximize the effectiveness of the teaching and learning processes as well as students' motivation to learn science.

The implementation of the new pedagogical standards in the science classroom implies the prerequisite of matching to each technique an assessment tool to measure students' achievement and progress. Gitomar and Duschl (1998) wrote that

"The most promising efforts in assessment reform are those that address directly the relationship of assessment and instruction, specifying precisely how assessment can be used to support improved instructional practice."(p. 803)

In the past, only a small fraction of student learning and activities was assessed (Lazarowitz & Tamir, 1998). The final grades given to students were mainly based on their ability in paper and pencil tests. Students' achievement in other learning techniques in which they were involved such as inquiry in the science laboratory, students' group and personal projects, reading of scientific articles, and many other instructional activities were rarely assessed and included in students' final grades. This was usually due to lack of valid and reliable criteria as well as suitable assessment tools for these learning components. Another problem is that teachers are less confident in using alternative assessment methods; there is a need to train teachers to change the methods of teaching chemistry, in general and the ways to assess their students' achievements and progress, in particular.

THE STUDY

An experimental project was conducted in Israel in one high school, aimed at bringing about changes in the way chemistry is taught through new pedagogical and assessment standards. The goal of the project was to bring about changes in the way chemistry is taught through new pedagogical and assessment standards.

The study was initiated in 1995 as a part of a nation-wide research project, involving 22 schools in which an alternative assessment of students was tried out. The idea was that these school-based assessment procedures, planned and implemented by the school teachers would replace the national matriculation ('Bagruth') examinations, that are created by the Israeli government (as part of the central education system that exists in the country) which are administered at the end of the 12th grade. Because of its structure, the 'Bagruth' covers only a limited scope of students' cognitive abilities and learning experiences (mainly assessed by a one-time paper and pencil testing). The theory behind this project was that the assessment should be valid and reliable, authentic (close to the students' way of learning), and comprehensive, i.e. should cover a wide range of abilities and ensures the acquisition of a wide range of learning goals.

THE CHEMISTRY PROJECT

The chemistry project[1] took place in an urban type high school, representing 100 students who studied chemistry between the 10th and 12th grades (The same cohort over a period of 3 years). These students opted to major in high school chemistry. In the 10th grade the students studied chemistry for 3 periods per week and 8 periods per week in the 11th and 12th grades, respectively.

Regarding the content of chemistry, the project was based on the ordinary syllabus used in high schools in Israel. A team of nine chemistry teachers from this high school was involved in this project. They were led by the school chemistry coordinator (head of department) and guided by an experienced teacher (tutor) who was appointed by the government to provide guidance in conducting the project. Together, they were involved in the development of the course and its teaching and in the design of relevant assessment tools. Amongst the assessment tools developed by the team were tests, quizzes, and assessments of inquiry type experiments and mini-projects. The teachers determined the weights given to each of the assessment criteria in order to increase the objectivity of the assessment. The role of the tutor and the coordinator was to enhance the team's confidence regarding the importance and effectiveness of the project. In fact, they acted as guides for what could be regarded as long-term, dynamic, school-based professional development of the chemistry teachers' team. The team also served as an "open platform" for dealing with problems that emerged in the teachers' daily work. This platform supported the development of an environment of collegiality, in which it was possible to reflect on one's work and to critically evaluate different pedagogical ideas and alternative methods for students' assessment was possible. During the years of the project, the teachers in the team developed the ability to cooperate and to communicate which became a model for other schools.

It is suggested that this project could be regarded as an action research which nowadays is seen as central to the restructuring of schools and as a strategy for professional development (Holly, 1991). In this context Loucks-Horsley et al. (1998) claimed that one of the forms of action research is when teachers are working together in inquiry and collaborative teams to attain certain pedagogical goals and to bring about change in classroom practice. The team was given time and support from the school administration to develop the program. Access to research resources for the development was provided by the tutor from the 'National Center for Chemistry Teachers' at the Weizmann

Institute of Science. Finally, the team was given opportunities to share the results of their project at chemistry teacher conferences that were held in various centers throughout the country. According to Loucks-Horsley et al. (1998) these three factors (time, resources and ability to share results) are vital for action research to be successful and beneficial. Table 1 describes the correspondence between teaching and learning objectives and the method of assessment that was used in the 'alternative chemistry assessment' project resulting from the team's collaborative discussions and decisions.

Learning Objectives **Tools**	**Tests**	**Quiz**	**Work on articles**	**Inquiry type experiments**	**Mini-projects**
Knowledge, comprehension and application	✓	✓		✓	✓
Understanding of relationship between chemistry and the environment	✓		✓	✓	✓
Development of thinking skills in chemistry			✓		✓
Understanding of inquiry methods (and abilities) used in chemistry				✓	✓
Understanding of the industrial applications in chemistry	✓		✓		
Understanding of the nature and history of chemistry			✓		
Development of scientific thinking			✓	✓	✓
Development of practical (laboratory) abilities				✓	✓
Using sources of information					✓
Development of inquiry skills				✓	✓
Development of critical reading skills using			✓		✓
scientific articles					
Presentation of information, results, and data			✓		✓
Development of the ability to work individually					✓
Development of ability to communicate scientifically with peers.				✓	✓

Table 1: Assessment categories in chemistry

Students' and teachers' attitudes and perceptions towards the project

Following three years of the project the team of teachers administered a questionnaire aimed at probing into students' attitudes and perceptions regarding the program in which they were involved.

In general, it was found that the students who participated in the project were satisfied with the way they learned chemistry. Clearly the project established a healthy learning environment in the chemistry classroom. These findings are especially important in an era in which creating an effective and a better classroom learning environment is becoming a major goal.

Regarding to the teachers who participated in the program, the project significantly changed their perceptions of their role as chemistry teachers in an era of reform.

GENERAL SUMMARY

We are operating in an era in which achieving scientific literacy for all has become a national goal in many countries. Although admirable, it represents a challenge for science teachers and for those responsible for professional development. To achieve this goal, there must be a reform in the way science is taught in schools and in the strategies used to professionalize science teachers in general and by the development of leadership among science teachers in particular.

One of the more effective methods to attain the goals of reform and its proper implementation is to actively involve the teachers in the curricular processes. Action research is only one of many effective strategies (Loucks-Horsley et al'. 1998) that could be used in order to effectively prepare the science teachers to cope with new content and pedagogical standards. Having a long and varied history, action research was first introduced by Kurt Lewin in 1940s. However, only in the last 10 years have we discovered the potential that this strategy has in our effort to bring about change in the science classroom.

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Professional Development of Science Teachers through Action Research

Brian E Woolnough
Oxford University, Department of
Educational Studies, Oxford, UK
brian.woolnough@edstud.ox.ac.uk

1. INTRODUCTION

In the UK, and other countries, there has been criticism of much of our training of teachers, including science teachers. It is said that the training is too academic, too far removed from the reality of the classroom, and too didactic, purporting to tell trainee teachers what they should do and how they should teach. Such a model was always suspect, in that it suggested that there was a single way of teaching physics which was best, independent of the attributes of the teacher, the pupils and the school. This model is particularly inappropriate at a time when we are training teachers to teach in a rapidly changing world, and for rapidly changing schools. The schools of tomorrow, the needs of the pupils of tomorrow, will be quite different from the schools of today and the needs of the pupils of yesterday. Consequently we must seek to prepare our teachers as autonomous professionals prepared to cope with, react to and lead the education to meet the changing needs of their rapidly changing world. In the UK, there have been significant changes made to our initial teacher training programmes [DfEE 1998], lead in many significant ways by the developments in our Oxford University Department of Educational Studies [Benton 1990, Allsop et al 1997]. There has also been a re-emphasis on the needs of practising teachers, in Continuing Professional Development programmes [DfEE 2000b]. It is aspects of these developments, showing how science teachers can be trained and subsequently helped to develop as self-evaluating professionals through action research, that will be described here.

In the UK, and other countries, there has been much criticism of the quality of educational research done in university departments of educational studies [Hargreaves 1996a and b, Tooley 1998]. It is described as "not making a serious contribution to fundamental theory or knowledge; being irrelevant to practice; unco-ordinated with any preceding or follow-up research; and which clutters up academic journals that virtually nobody reads" [Hargreaves 1996a, p7]. It is argued that research should be done in the schools, and be relevant to the questions that are important to teachers and their schools, and that teachers should be involved with that research themselves. That researchers should be doing research *with* teachers, not *on* them. Indeed that teaching itself should become a research-based profession. In this way, and only in this way, Hargreaves [1996a, p1] argues "teaching would become more effective and more satisfying".

2. THE CONCEPT

The concept of science teachers as a self-evaluating professionals, incorporating action research as an integral part if their own teaching, addresses both of these issues. It provides a training for teachers which is school based, forward looking and professional, and at the same time provides research insights which are focussed onto real students learning real science with real teachers in real school. More importantly it encourages a professional way of teaching, continually seeking to improve ones own practice. As Jenkins (2000) says "educational research is a mode of thinking rather than a short-cut to answers". "It sharpens thinking, directs attention to important issues, clarifies problems . . .thereby preventing ossification of thinking and adaption to changing demands" (Nisbet, 1974).

Self-evaluating professionals will continually consider their own practice, evaluate it and modify their practice accordingly. Good teachers have done this tacitly throughout their teaching, I suspect that is why many of us found teaching so satisfying as it became a succession of problem solving exercises: how best (how better!) can we teach a difficult concept or a reluctant pupil? But we would go further and encourage the trainee teachers to be more explicit about this. Throughout their training and their professional life, they should consider aspects of their teaching, to try particular strategies, to get evaluation from their mentors, their colleagues and their own data, and hence to modify and improve their practice. As this becomes a systematic habit, a growing body of evidence will build up which will produce patterns of good practice and start producing fundamental insights and theories into how teachers teach and students learn best. We are increasingly incorporating this approach throughout our training, believing that motivated adult learners learn best when they are active in and have ownership of their own learning, in exactly the same way as we believe children do.

3. THE TRAINING CONTEXT.

In the UK, science teachers are taught via the post-graduate route. Most secondary teachers will have done a science or science related degree course first and then will do a one year professional training based jointly in a university Department of Educational Studies and a local secondary school. Their programme for this year will be planned jointly between the Tutors at the university (normally ex-school teachers), and the Teachers (mentors) in the schools. Typically they will spend about 1/3rd of their time in the University and 2/3rds of their time in the schools, concurrently. The course will focus on the practicalities of teaching, the pedagogy, the knowledge that the pupils need to know, the ways that pupils learn and are motivated, and the ways that teachers plan and manage classes, teach and assess pupils progress. The trainee teacher will need to demonstrate their competence in all of these areas, largely through their practice in schools. After completing the professional training year, and attained QTS (Qualified Teacher Status), the scientist will commence teaching in the science department of a school of their choice, and may subsequently receive some continuing professional development (CPD) either in school or at a local University or other training institution. Such professional development has in the past been very haphazard and teacher-driven. Increasingly the profession is taking more responsibility for the CPD of its members. In this paper I will describe the way that we provide a distinctive form of initial training (PGCE) and professional development (CPD), encouraging the teachers to become self-evaluating professionals.

i) PGCE

Though we have recently had imposed on the system a National Curriculum for Initial Teacher Training [DfEE, 1998], we still insist that it is our job to help the trainee teachers find the most appropriate way for them to teach, not to impose a single pattern on them all. Throughout the course, we set standards and tasks, and expect the students to explicitly evaluate their own practice. We will expect them to have a specific focus for their lesson, (concentrating perhaps on organising apparatus, or starting and concluding a lesson, or developing questioning skills, or evaluating how much pupils have learnt etc) and then to reflect, quite explicitly on that aspect of their teaching. We find it more helpful to encourage them to focus on a particular aspect of their teaching rather than to try and evaluate the whole, highly complicated business of teaching at one time. The school mentor and the curriculum tutor from the university will help them evaluate their [progress through out the year. Towards the end of the year, one of their assignments asks them to take an aspect of their teaching, to set up a programme in the classroom with their pupils, and to do a small research investigation into its effectiveness. They will choose the aspect of their teaching that is of most concern to them. Typical aspects would be:

- homework or pupils written work, in which the student would set different types of task and evaluate the effectiveness of each;
- different teaching styles, in which the student would evaluate the effectiveness, for different pupils, of the different teaching strategies they had used;
- formative assessment, in which the student would seek to modify the teaching programme to match the pupils individual progress.

In each case the evaluation would be based on an analysis of the data, pupil questionnaires and/or interviews. They will also read around the relevant literature in the area, to gain both an overview of the topic and an in-depth appreciation of their own practice.

One type of investigation which is always effective asks the pupils to reflect on the effectiveness of different types of teaching strategy that they have experienced, in respect to how much they have enjoyed it and how much they think they have learnt from it [Woolnough et al, 1999]. It is surprising how much pupils are able to differentiate between learning and liking. Consistently they will say that there are some types of teaching they like more whilst other types of teaching they learn from more. Though the exercises are not extensive, with small samples and uncomplicated research methodology, the very act of involving the students in such systematic self-evaluation raises important insights and further questions for them, and develops a highly professional approach in which they take ownership, full responsibility, for their own teaching. As motivated, adult learners, this is highly appropriate.

ii) CPD

Over the last three years we have offered local science teachers a part time, postgraduate diploma course in Developing Science Education in Schools. This has lasted two years, with two evenings and one Saturday morning teaching in the Department each term, assignments and school-based investigations of their own practice in their own schools. These investigations have been at the heart of the course, and have trained them to be 'teacher-researchers' in their own schools, of their own practice. Again, we are building on their PGCE approach so that they can become systematic, self-evaluating, professionals taking responsibility for their own teaching and producing a body of research evidence relevant both to their practice and to teachers on other schools. This year's investigations cover such as:

- Teaching controversial issues in science;
- Developing self-directed review practices for end of topic revision;
- Investigating pupils preferred teaching styles;
- Evaluating the effectiveness of industry-linked, student research projects;
- Investigating the effect on student learning in science of pupils changing schools at age 11.
- Teaching the moral, spiritual and cultural aspects of science;
- Investigating pupils attitudes to science;
- Evaluating assessment practices in schools, formative and summative;
- Matching learning strategies to pupils' motivational and cognitive needs;
- Investigating strategies for increasing literacy skills through science.

4. MAKING IT WORK

Teachers in the UK, as in other countries, are very busy people, with increasingly many external pressures to 'deliver' a given national curriculum, to obtain good exam results, and to obtain a high place in the local, national, or TIMSS league tables. Why should they seek to go further, to move from being a technician delivering a product to seek to become self-evaluating professionals. Primarily, this must be to satisfy their own professional pride, to do the best they can in the profession they have chosen. Beyond this underlying intrinsic motivation, they will need extrinsic recognition through the approach being an intrinsic part of a validated course. This we have been able to provide with our own PGCE, PGDES and MSc courses. They must also get recognition for this in their own school, and we have found that this is being increasingly given where the Head, the whole school and / or the teachers science department are involved with the project from the beginning. A teacher trying to plough a lone furrow in an unsympathetic school will soon become disillusioned. And they will need expert and sympathetic support from an experienced Tutor and researcher, normally from the local University. It will also need financial support, for the work being done in schools and especially for paying the Tutors for their teaching and support. Fortunately, in the UK, the DfEE of the government has recognised this as being important and is increasingly prepared to fund it. (eg the Best Practice Research Scholarships of the DfEE, 2000).

We believe that this approach is producing more fulfilled teachers, more effective teaching and more relevant and valid research insights. Thus science teachers, as well as science teaching, will develop through using action research as an integral part of their on-going professional life.

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A Longitudinal Study of Junior High School Students' Perceptions of the Particulate Nature of Matter

Hanah Margel, Bat-Sheva Eylon, and Zahava Scherz*,
The Weizmann Institute of Science,Rehovot, Israel,
zahava.scherz@weizmann.ac.il

This study investigates the changes in JHS students' conceptions of the structure of matter as they study the subject of "materials" using a new curriculum in Science and Technology. The new instructional method is based on a student–centered constructivisitic model and on a "spiral" approach to the learning of fundamental concepts. The sample consisted of an experimental group of 1084 JHS students who studied "materials" according to the new curriculum, and a comparison group of 218 JHS students who studied this subject according to a traditional curriculum. Questionnaires, in which students were asked to represent the structure of several materials, in words and pictures were administered five times during a 3–year period. The results indicate three main mental models regarding students' conceptions of the structure of matter: Model A– materials are continuous substances. Model B– substances consist of particles. Model C– substances consist of various molecules. The experimental group underwent a process of conceptual change regarding the structure of materials: More than 80% of the students moved from model A to model B, and 50% succeeded to move on to model C.

INTRODUCTION

In 1996 a new unified subject called "Science and Technology" was introduced to junior high schools (JHS) (grades 7–9) in Israel. The aim of this new subject is to cultivate scientific and technological literacy for all citizens as well as to prepare students with the necessary background for further studies (Israeli Ministry of Education, 1996). To this end, a new syllabus was developed. "Science and Technology for JHS" includes seven main topics: "Materials", "Energy", "Living Organisms", "Earth Systems", "Ecology", "Technology" and "Communication". The new syllabus covers three years (7–9 grade) – 180 hours each year.

The Department of Science Teaching at the Weizmann Institute of Science established the MATMON group to develop a new curriculum for "Science and Technology". The new curriculum focuses on a thorough understanding of basic concepts in science and technology and emphasizes the development of independent learning skills within the subject matter. More specifically, it includes learning skills associated with knowledge acquisition, scientific and technological reading, listening and writing, as well as knowledge representation and presentation. The inquiry capabilities consist of investigation and problem-solving skills and technical skills. The acquisition of capabilities is built in the context of the units.

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* Corresponding author.

"Materials", one of the main topics included in "Science and Technology" is intended to cover 105 hours in grades 7–9. MATMON's new curriculum in "Materials" emphasizes the longitudinal development of several interrelated concepts frameworks along 7–9 grades – within and between disciplines. For example: learning about matter involves a major framework relating to structure, properties, and applications of materials, which can be discussed macroscopically and microscopically at different levels. One of the basic principles of materials science is the structure of matter. This subject provides students with a better understanding of daily phenomena and helps students form a solid scientific and technological basis for future studies.

The particulate nature of matter, a most fundamental concept in science, has been traditionally introduced at an early stage of JHS science. However, numerous studies have consistently shown that many JHS as well as HS students have conceptual difficulties in understanding the ideas associated with the particle theory (Anderson, 1990; Ben Zvi et al., 1986; Brook et al., 1984; Driver et al., 1994; Gabel, 1993; Johnson, 1998; Millar, 1990; Novick & Nussbaum, 1978; Renstorm et al., 1990).

We therefore decided to develop new instructional materials aimed at improving students' conceptualization of matter.

In this paper we describe a longitudinal study of junior high school students' conceptions of the structure of matter as analyzed through their learning the topic "Materials" according to our new MATMON curriculum.

DESCRIPTION OF THE NEW LEARNING UNITS OF "MATERIALS"

The new instructional program dealing with the topic "materials" includes several units (see table 1). The main features of these instructional units are as follows:

- Development of a fundamental understanding of central concepts such as the particulate structure of matter, the atomic model, and the relationship between the structure, properties, and applications of materials.
- Integration of the macroscopic view with the microscopic world. providing a molecular explanation for the structure and properties of materials.
- Use of models to explain the structure of matter. The students are encouraged to use a variety of models (e.g., building blocks, computer simulation, and theoretical representations) In order to understand the structure of matter, the meaning of a model,

is discussed including its advantages and limitations.

- The units integrate aspects of sciences, technology and society.
- The units encourage the development of independent learning and inquiry skills.
- The units encourage project–based learning with content knowledge.
- The units provide a wide range of learning activities in class with an emphasis on active pupil involvement in lessons.

In this paper we focus on our instructional methods aimed at developing students' understanding of the particulate structure of matter, and the relationship between the structure, properties and applications of materials. In particular we tried to emphasize, recall and reinforce these concepts and ideas in all our instructional units. This approach requires special teaching methods and necessitates an extended period of time.

Table 1: MATMON instructional units of the subject "materials" and their main topics.

Teaching unit	Academic year	Main topics
"The Structure of Matter: Vacuum and Particles" (Nussbaum, 1996)	7	Properties and applications of materials; the relationship between the properties and applications of materials. Particle model; states of matter: gas, liquid and solid; changes of state; Explaining phenomena according to the Particle theory.
"From Elementary to Complex Structure" (Scherz et al., 1997)	8	Atoms, molecules, size and units, elements, models. Structure of the atom; compounds, mixtures, the relationship between the structure and properties of materials.
"About Fibers" (Margel, 1997)	8 or 9	Structure, properties, and applications of fabrics, threads, fibers, polymers, and composites; the relationship between structure, properties, and applications of materials.

In order to improve students' understanding of the structure of matter, we integrate this subject several times, applying a "spiral" model. The spiral development of our instructional method evolves from the seventh to ninth grades in the following manner: The particulate model of matter is introduced in the seventh grade through the learning unit "The Structure of Matter: Vacuum and Particles" (Nussbaum, 1996). The central concepts are taught using a constructivistic approach including student debates and laboratory experiments. "The study of the particle model is a lengthy process of conceptual change. Conceptual changes require an extended period of time. Teachers should apply certain strategies and methods that involve students in constructing the desired meaning of scientific concepts and which help the students undergo the desired conceptual changes." (Nusbaum, 1998). In this unit there is a relatively constrained discussion of the different states of matter, emphasizing constructing the concepts of vacuum and the particulate, rather than the continuous model of matter.

The next learning unit from "Materials" is "From Elementary to Complex Structure" (Scherz et al., 1997), usually taught in eight grade. The main topics in this unit are: atoms, molecules, size and units, models, elements, structure of the atom, compounds, mixtures, and the relationship between the structure and properties of materials. Based on the particulate model of matter, this unit introduces some molecular structures related to elements: (oxygen) compounds (water) and mixtures (air). In this unit the particulate structure of matter is extended when students learn to distinguish between the types of particles. In this way, we emphasize, recall, and strengthen the particulate structure of matter within the instructional unit. At a later stage the particulate structure of matter is further developed in the unit "About fibers" (Margel, 1997). In this multidisciplinary unit, which presents major scientific and technological concepts, the students study the molecular structure of polymers, and learn the relationship between the structure, properties, and applications of materials as implemented in fabrics, threads, fibers, polymers, and composites. In all the stages, the particulate model of matter is stressed.

Other related programs, such as materials in living organisms and in earth systems are studied in a coordinated manner.

THE RESEARCH

The main goal of this research was to study the changes in JHS students' conceptions of the structure of matter when they learned the topic "Materials" using the new MATMON curriculum. One question that was addressed was whether students who studied the subject "Materials" by using the MATMON curriculum had a better understanding of the concepts and fewer learning difficulties than those who studied the same subject using the traditional materials. Another question was whether and to what extent students retained what they had learned 6–12 months after they finished learning the topic "Materials"

The research sample consisted of two groups of junior high school students: (1) an experimental group of 1084 junior high school students who studied this topic according to the new curriculum using the units "The Structure of Matter: Vacuum and Particles", "From Elements to Complex Structure", and "Fibers"; (2) a comparison group of 218 students who studied "Materials" according to the old curriculum, which covers the same topics and concepts but uses a different learning approach.

The principal research tools were questionnaires in which students were asked to describe in words and to draw the structure of several materials: iron, water, air, nylon, strawberry juice, wool, oxygen and paper. The students were specifically asked to relate to the structure of those materials as if they were looking at them through "magic glasses" which enable them to "see" their structure.

The questionnaires were administered five times to the students during a 3–year period (grades 7 –9).

Test A: Given at the beginning of 7th grade before studying "Materials".

Test B: Given after students in both groups had studied about the particulate nature of matter.

Test C: Given after students in both groups had studied about atoms, molecules, elements, compounds, and mixtures.

Test D: Given to the experimental group after they had studied "About Fibers".

No test was given to the comparison group because the students did not study a similar program.

Test E: Given in 9th grade, 6 months after both groups had studied the subject "Materials"

MAIN FINDINGS

Most students expressed the particle nature of matter in drawing better than they explained it in words. Therefore, we decided to concentrate on the findings from students' drawings.

The macroscopic view: Figure 1 depicts the percentage of students who drew the structure of materials using the macroscopic view.

The results indicate that at the beginning of JHS (7Th grade) 60% – 80% of the students described the structure of materials on a macroscopic level. (The remaining 20% did not answer the question). In the experimental group the description gradually became less macroscopic, and toward the 9Th grade the structure of materials was rarely described by using the macroscopic view.

In the comparison group, even at the end of the study, 25% drew the structure of most materials in a macroscopic view and 10% of this group drew the macroscopic view of the well studied materials air and oxygen.

The particle structure: Figure 2 depicts the percentage of students who drew the particle structure of matter in tests A–E as they learned the topic "Materials".

Test A: The results indicate that at the beginning of JHS, students in both groups had no knowledge about the particulate nature of matter.

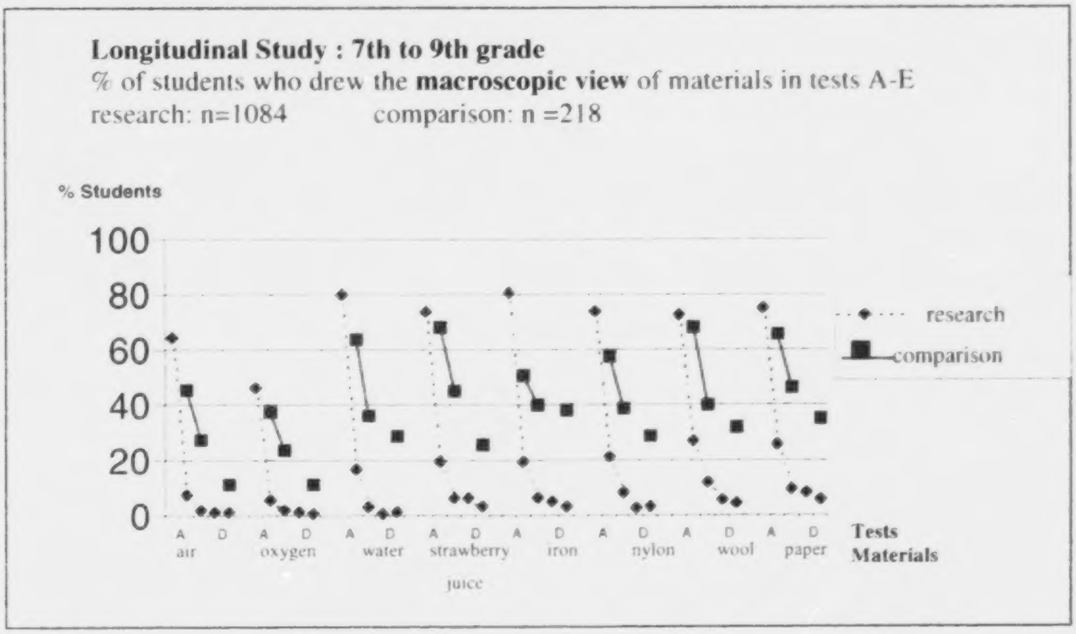

Figure 1: Students drawing the structure of materials in a macroscopic view

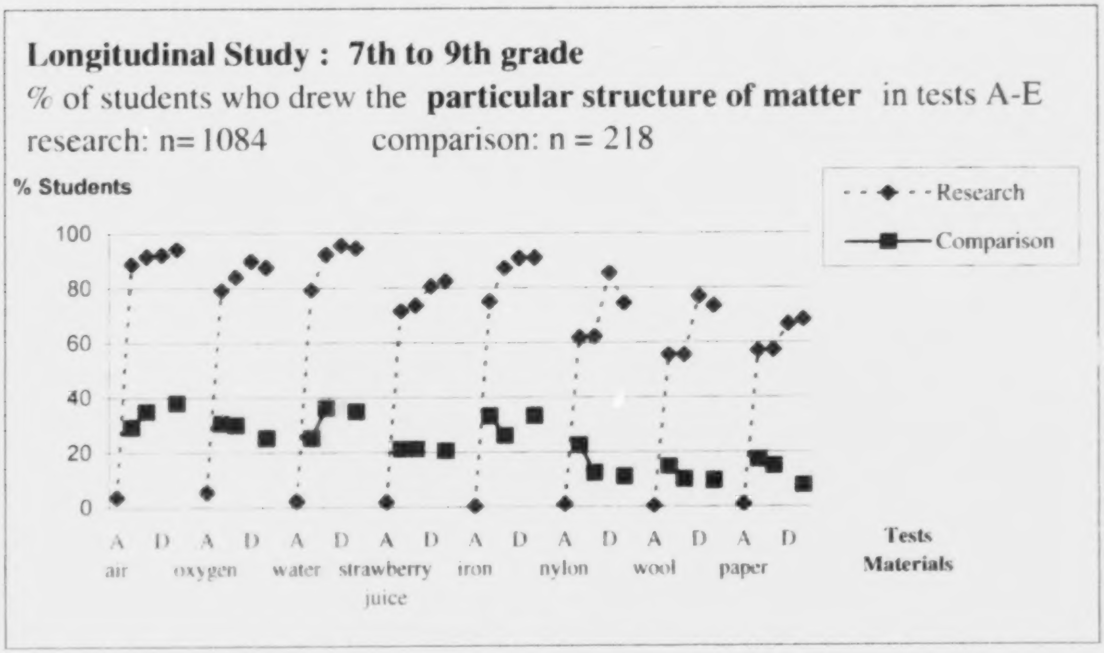

Figure 2: Students drawing the particle structure of matter

Test B: 60%– 80% of the students in the experimental group drew pictures of materials according to the particle theory. Only 30% of the comparison group students drew pictures of materials according to the particle theory.

Test C: There was another slight increase in the percentage of students in the experimental group who drew the structure of materials according to the particle theory, especially water and iron. Less than 40% of the students in the comparison group drew a particle picture of materials.

Test D: There was another slight increase in the percentage of students in the experimental group who drew the structure of materials. A more significant increase was evident in drawing the structure of nylon and wool according to the particle theory.

Test E: No significant change was observed in the experimental group's performance. Most of the students in the experimental group (70%–90%) drew materials according to the particle theory. A slight decrease was apparent in students' drawing of nylon and wool. Less than 40% of the students in the comparison group drew the particle structure of materials mentioned in class such as iron, water, and oxygen and less than 20% drew nylon, wool, and paper according to the particle theory.

The molecular structure: Another aspect of the particulate structure of matter is the "Molecular Structure of Materials". In this model students consider the particulate structure of materials and distinguish between the types of particles. Figure 3 depicts the percentage of students who drew the molecular structure of materials in tests A–E when they learned the topic "Materials".

Tests A and B: The results indicated that in the 7th grade, students in both groups had no knowledge about the molecular structure of matter.

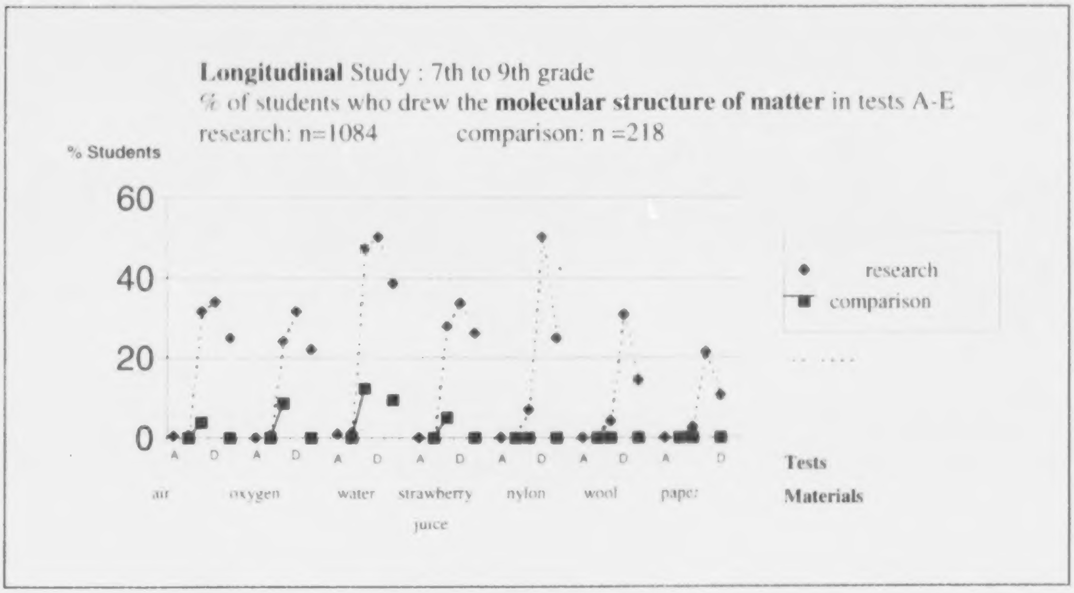

Figure 3: Students drawing the molecular structure of materials

Test C: There was an increase in the percentage of students in both groups who drew the molecular structure of air, oxygen, and water. The students' drawings referred to the differences between the molecules of the substances. Specifically, the students drew water as molecules of three atoms (two identical and one different) and oxygen as a material consisting of molecules of two identical atoms. 50% of the experimental group students drew the molecular structure of water, and more than 30% of this group drew correctly the molecular structure of air, oxygen and strawberry juice as a mixture. However, only 10% of the students in the comparison group drew correctly the molecular structure of air, oxygen and water. The students in both groups did not draw differently the structure of nylon, wool and paper and other solids.

Test D: There was a significant increase in the percentage of students in the experimental group who drew the molecular structure of nylon and wool correctly.

Test E: There was a decrease in students' ability to draw the molecular structure of materials. 40% of the experimental group and only 10% of the comparison group students drew the molecular structure of water. Most of the comparison group students did not draw differently the particles of most materials.

DISCUSSION

The research results indicated that the students who studied "Materials" according to the new Science and Technology curriculum underwent a process of conceptual change regarding the structure of materials.

Students' view of matter moved from the macroscopic level toward the microscopic level.

All students entered JHS (7th grade) without any knowledge of the particulate nature of matter. Their description of the structure of materials was always on a macroscopic level. Gradually the description became less macroscopic, and toward the 9th grade the structure of materials was always described using the microscopic view.

In the comparison group, who used different teaching units for this topic, there was a slight increase in the percentage of students who described the particulate view of materials, with a significant difference between the two groups in favor of the experimental group.

We can identify three main mental models regarding students' conceptions of the structure of matter:

Model A: "Continuous substance". According to this mental model students consider materials as continuous substances. They draw the structure of materials using the macroscopic view.

Model B: "Basic particle model". According to this mental model, students consider materials as substances consisting of particles without distinguishing between the types of particles.

Model C: "Molecular structure model". According to this mental model, students elaborate the particle model and distinguish between different types of particles.

Clearly, students in the experimental group improved their understanding of the structure of matter in their 3 years of studying materials in JHS. More specifically, 75%–95% of the experiment group students changed from the continuous substance model (model A) to the basic particle model (model B). For example, they changed in considering water as a continuous substance (model A), to its being composed of particles (model B). The retention of the basic particle model was very high. These results show that students understood and internalized the basic particle model.

About half of the experimental group students changed from model A to model C. For example, these students correctly described the molecular structure of water and even the structure of polymers, such as nylon. However their retention of the molecular structure model was less than that of the basic particle model. The possible explanations for this finding are: (a) The molecular structure of matter was studied at a later stage (8th grade). (b) The students had to use their memory in order to draw the molecular structure of different substances. They succeeded in doing it close to the actual instructional period, but had difficulties in drawing the detailed molecular structure a few months later. We believe that most of these students do have a correct concept of the molecular structure of matter even if they cannot draw the specific molecular structure.

In the comparison group, a smaller number of students changed from model A to model B, but very few reached model C, and were not able to distinguish between the types of particles.

Piaget and Inhelder (1974) reported on the development of "atomistic" ideas in children's thinking, at ages 11–12. Fensham claimed that particle concepts are "too difficult" (Fensham 1994). The evidence presented in this study suggests that the particle concept can be successfully taught in junior high school using meaningful learning and appropriate methods of teaching. One method is to teach the particle theory constructivistically. The study of the particle model is a lengthy process of conceptual change (Nusbaum, 1998) which requires an extended period of time. Teachers should apply appropriate strategies and methods that involve students in constructing the desired meaning of scientific concepts and which help them undergo the desired conceptual changes.

An additional method is to teach this subject based on a "spiral" model, which involves teaching the topic in several steps, so that at each step, the basic ideas are presented, repeated, and refined, and consequently, a deeper and more meaningful understanding is acquired.

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Project-Based Learning (PBL) in Science and Technology: A Case Study of Professional Development

Sherman Rosenfeld, and Yehuda Ben-Hur,
Weizmann Institute of Science, Rehovot, Israel
ahava@inter.net.il, b_yehuda@zahav.net.il

Project-Based Learning (PBL) is "a teaching and learning model that focuses on the central concepts and principals of a discipline, involves students in problem-solving and other meaningful tasks, allows students to work autonomously to construct their own learning, and culminates in realistic, student-generated products" (Thomas, et al., 1999).

Despite the educational potential of PBL, it is clear that without providing proper attention to teacher development and school change, actualizing this potential will remain a dream (e.g., Marx, et al., 1997).

Our case study focuses on one approach to the professional development of science and technology in regard to PBL. First, we present the rationale and goals of our approach. Next, we describe the context, population and methods of our case study.

We present the sequence of the PBL Teacher Workshop, the resulting teacher projects in science and technology, and phenomena of note in the workshop. Finally, we discuss our findings and their relevance for practice in the professional development of science and technology teachers.

1. RATIONALE AND GOALS

"Project-Based Learning (PBL) in Science and Technology" is a constructivist method of teaching and learning that has been developed at the Department of Science Teaching at the Weizmann Institute of Science. Based on prior research about how teachers change (Rosenfeld, et al, 1997), our 3-stage approach focuses on supporting teachers as (1) learners of PBL, (2) practitioners of PBL in their classrooms, and (3) innovators of PBL in their schools.

The present study focuses on the first part of this 3-stage process. We present a case study of teachers as they are supported as "learners of PBL" in a special PBL Workshop. Our guiding goals are:

(a) to describe and document what happened during the workshop, and

(b) to analyze the potential of this approach for science education.

2. CONTEXT, POPULATION AND METHODS OF THE STUDY

For the past 7 years, a national reform effort has been undertaken to improve science and technology education in Israel. Part of this effort has involved the design and implementation of long-term teacher inservices (3 years, 540 hours) for teachers in middle schools.

One such long-term teacher inservice was organized at the Netanya Teachers Center between the 1997-2000 school years for 26 teachers of science and technology from the Arab sector. The inservice was held in the village of Tira for teachers from Tira and the surrounding villages.

As part of this inservice, a 10-lesson (30-hour) workshop on "project-based learning in science and technology" was given throughout the 1999-2000 school year. The authors of this article were the instructors of this workshop.

We used a variety of methods to document the workshop, the resulting teacher projects, and the reactions of teachers: observations, interviews, teacher feedback forms, and an analysis of the teachers' portfolios and final projects.

3. CONTENT AND SEQUENCE OF THE PBL WORKSHOP

In order to combine the learning of PBL skills with the learning of specific content, the teachers were first taught the central concepts and principles of a learning unit on the subject of the water cycle on Earth (Asaraf-Ben-Tzvi and Orion, 1999). The teachers were also taught skills related to "scientific communication" (Scherz and Spector-Levi, 1999). We then conducted our PBL workshop. During this workshop, teachers were asked to define, design and implement science and technology projects of their choosing, on the subject of water.

The PBL Workshop was based on having the teachers undergo a series of guided activities. In each activity, teachers were asked to produce "mini-products" (e.g., a list of questions, a leading question, appropriate references, a reseach design, a proposal, etc.) which progressively contributed to the production of the final project.

a. Asking Questions. (We designed an exhibitition of experiments, articles, equipment and challenges to elicit teacher questions relating to water.)

b. Choosing a Leading Question.

c. Locating and Reading Relevant Background Material.

d. Defining a Research Question or Design Problem.

e. Designing an Appropriate Methodology.

f. Writing a Project Proposal. (Teacher proposals were evaluated by peer-review as well by the instructors.)

g. Implementing and Documenting the Work.

h. Analyzing the Data and Drawing Conclusions.

i. Writing the Final Report.

j. Presenting the Projects.

During each stage, the instructors presented relevant activities, based on a PBL guide written for students (Breiner, Rosenfeld and Fallik, 1999). The teachers recorded and documented their work in loose-leaf portfolios.

4. THE TEACHER'S PROJECTS

As can be seen from the following table, the projects were varied, both in terms of topics and methodologies used. It should be appreciated that each project has its own 7-month history.

Project Topics	Methodologies Used
The Design of a Home Device for Softening Water for Washing Machines.	Invention, model-building, experiments.
A Comparison of the Working Mechanisms of Different Devices to Purify Drinking Water.	Model-building, survey.
A Study of the Most Popular and Most Effective Computerized Irrigation Systems.	Survey.
The Mediteranean Sea-Dead Sea Canal: Historical, Economic, Social and Environmental Aspects.	Academic literature review and model-building
Water Purification Systems for Home Use.	Survey.
The Effect of Different Concentrations of Saltwater on the Growth of Plants.	Experiment.
Examining the Effectiveness of a Home Water Purification Device.	Experiment.
A Study of Computerized Irrigation Systems.	Model-building and survey.

5. PHENOMENA OF NOTE

As a result of our observations and interviews, we noted a number of interesting phenomena:

a. *Team Formation.* The formation of project teams was not without conflict. At times, we needed to help these groups resolve their differences. However, each team eventually improved its cooperative work, resulting in a clear division of labor among the team members.

b. *Affective Aspects.* As predicted in past research (Rosenfeld et al., 1997) the teachers progressed from initial excitement to confusion and frustration, followed by fulfillment A month before the end of the workshop, the teachers said wanted to cancel the conference. Our reaction was that the conference would take place and that we would give them extra help. The conference did take place, the oral and written presentations were superb, and the teachers ended the workshop with a tremendous feeling of accomplishment.

c. *Skills-Based Difficulties.* Despite the positive outcome of the workshop and the generation of successful projects in science and technology, the teachers experienced a series of skills-based difficulties in the process, including asking focused research questions, matching these questions with the appropriate experimental methods, conducting the statistical analysis, and making conclusions based on the available data.

d. *The Integration of Science and Technology.* Most teacher projects integrated aspects of science with aspects of technology. Technological issues (e.g., those relating to water purification and computerized irrigation systems) were the springboard for the teachers to deepen their knowledge about basic scientific concepts and principles.

e. *The Promise of School Change.* Throughout the workshop, the teachers expressed interest in bring PBL into their classrooms and schools. Project-Based Learning is a novel educational pedagogy in the Arab sector in Israel. As a consequence of their "hands-on" exposure to this approach, the teachers were generally enthusiastic about PBL and filled with enthusiasm regarding its future promise. As one teacher noted::

"I hope that this way of learning (PBL) takes place in most of the schools in the Arab sector, because it's a way for teaching students to think like scientists and to turn into citizens who are aware of what takes place around them in the age of the computer and the Internet, and not to become citizens who are like passive 'tape recorders' that just receive information."

6. DISCUSSION AND CONCLUSION

The case study presented above highlights a number of important issues. First, it highlights the educational potential of the PBL approach. The teachers were quite enthusiastic about PBL and expressed their desire to see it implemented in their classrooms. Second, it highlights the difficulties experienced by the teachers during their PBL workshop (e.g., team-formation, affective aspects, skills-based difficulties).

Research has shown that classroom students experience these difficulties during the PBL process (Thomas, et al., 1999; Marx, et al., 1997). Third, it emphasizes the importance of providing a support system for teachers who want to learn and implement the PBL process in their classrooms.

These three issues -- the educational potential, difficulties and support system related to implementing PBL in science and technology -- reinforces the rationale behind our teacher development program. As mentioned at the beginning of this paper, our rationale is based on the recognition that teachers need support at three consecutive (and sometimes overlapping) stages in their development: as learners of PBL, as teachers of PBL in their classrooms, and as educational innovators (and agents of change) in their schools.

As learners of PBL, the teachers progressed from one stage to the next, experiencing various challenges along the way. These challenges (team-formation, affective aspects, skills-based difficulties, as described above) are typical to all PBL work (Thomas, et al., 1999; Marx, et al., 1997). By experiencing and dealing with these difficulties "in first person," our assumption is that they will be better able to help their students do the same when they engage in PBL.

As teachers of PBL in their classrooms, many different difficulties await our teachers.

For example, in an study of 12 expert PBL teachers, 7 major problem areas for PBL implementation were identified: (1) time management, (2) getting started, (3) establishing a culture that stresses student self-management, (4) managing student groups, (5) working with others outside the classroom, (6) getting the most out of technological resources and (7) assessing students and evaluating projects (Mergendoller and Thomas, 2001). We would add two other problem areas: teaching

PBL skills and balancing the teaching of PBL skills with the learning of subject-domain specific content. Of course, management principles for the practicing PBL teacher exist; the study of expert PBL teachers identified 53 such "classroom management principles." However, the systematic learning of these principles by practicing PBL teachers is not a simple matter.

As educational innovators, our teachers will be called upon to access and/or develop knowledge from such areas as organizational development and school change.

Well-respected and recognized experts in these fields talk about the immense difficulty of sustaining innovations within educational institutions. In the words of one such expert, the "traditional fate of innovations (include) dilution, withering, distortion, trivilization, (and) reversion to traditional practice" (Huberman, 1997). So the challenges to be faced in this area are not simple either.

Given these challenges, how might the professional development of teachers in PBL be promoted? Our anwswer to this questions is that a long-term system of support is needed to help teachers effectively learn and implement PBL.

One such long-term support system is described as the "interlocking loops" model of professional development (Rosenfeld, et al., 1999). Four target audiences are linked by three interlocking loops of support: (1) teacher teams support students (in their PBL work), (2) leading teachers support teacher teams (via in-service workshops and school guidance), and (3) teacher educators support leading teachers (via seminars and in-service guidance). In practice, the four audiences may be more flexible in their interactions than shown. Also, other audiences (e.g., principals, parents, community-based experts, etc.) may participate in the three support loops. (See Fig. 1 and Table 1.)

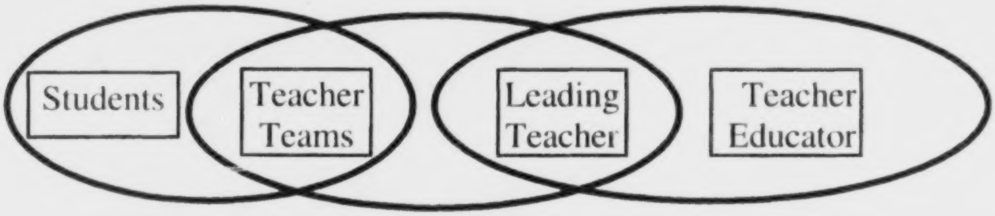

Figure 1. Interlocking Model of Professional Development in PBL

Despite the difficulties teachers experience in learning, implementing and institutionalizing PBL, the PBL approach has generating a great deal of teacher and student enthusiasm. The combination of student-generated questions with standards-based principles and concepts withinin a context research skills development is an appealing mix for teachers as well as students.

We conclude that "Project-Based Learning in Science and Technology" can be a significant catalyst for helping teachers to introduct "a new spirit" into science and technology education: focusing on learner-centered approaches to learning, integrating science and technology, providing an authentic project work, participating in cooperative staff work and learning how to learn.

This case study represents only the beginning of the 3-stage model for professional development we have adopted for our teachers ("the teacher as learner of PBL"). This school year we are supporting these teachers in the second stage (as "practitioners of PBL" with their students). The third stage of our model ("teachers as PBL innovators in their schools") is planned for the following school year.

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		A. Students	**B. Teacher Teams**	**C. Leading Teachers**	**D. Teacher Educators**
1.	**Major Goals**	PBL as a Learner	PBL as a learner PBL as a teacher PBL as an innovator	a. Teacher development b. Classroom support c. School support	a. Research and development b. Teacher development c.Organizational support
2.	**Major Difficulties**	Developing PBL knowledge and skills	Developing knowledge and skills relating to: a. PBL b. pedagogy c. school implementation	Developing knowledge and skills in teacher development as related to: a. PBL b. pedagogy c. school support	a. Setting goals and methods for PBL. b. Developing models for teacher development, classroom practice, school practice. c. Problems of scale.
3.	**Support Setting(s)**	Classroom	a. In-service b. Classroom c. School	a. In-service b. Classroom c. School	a. In-service b. Classroom c. School
4.	**Support Personnel**	Classroom Teachers	Leading Teachers and Teacher Developers	Teacher Developers	Other teacher educators and relevant professionals
5.	**Support Materials**	Student PBL Guide, Student Video, PBL software	Teacher PBL Manual, Teacher Video, PBL software	Examples and analysis of student PBL work; PBL Workshop Lesson Plans	Research and experience from other PBL efforts from around the world

Table 1. Four Interlocking PBL Audiences. These audiences (students, classroom teachers, leading teachers and teacher developers) are analyzed in terms of the setting in which they work, their major goals, major difficulties, who supports them, and support materials. The audiences are connected by interlocking support structures, i.e., teacher teams support students (in classrooms), leading teachers support teacher teams (during in-services and implementation support), and PBL developers support leading teachers (in workshops and seminars), as presented in Fig. 1.

Overcoming Students' Alternative Frameworks in Computational Exploratory Environments

Zoe Kavogli and Gordon Doughty
University of Glasgow, UK
zoekavogli@hotmail.com

ABSTRACT

Students enter university with deeply ingrained ideas about the nature of electricity. These ideas may be incorrect or inadequate, but provide a basis for further learning. This research focused on how to create activities integrated into normal classroom work, based on a pedagogical model which took into consideration the students' preconceptions and activated adequate strategies to improve their learning.

Software was designed based on a wide range of alternative frameworks, metaphors or models of electrical concepts, providing visible analogies and concrete visual models of simple electrical phenomena. It offered facilities such as animated pictures, calculations, graphics and problem-solving tasks, with frequent corrective feedback. A sample of 30 first year University students used this software, and were placed in conflict with their own models. They were required to type into the software their reasons for believing particular results. Through the software and with a tutor they were then encouraged to question their models, extending and modifying them as necessary, experiencing conceptual change so that learning took place.

While using the software students were frequently surprised when they discovered that they had answered incorrectly, often refuting this fact because of the confrontation with their own notions of basic circuit concepts. Then they attempted to modify their reasoning and started to talk each other and to the researcher – tutor. Skilfully-led discussions added to the dissonance, internal motivation and conceptual restructuring brought about the software.

Data was collected from observations, interviews, assessment tests (pre, post and delayed), questionnaires and analysis of typed-in reasons. The majority of students claimed that they gained another way of reasoning about electrical concepts. Many also claimed that they gained more understanding and clearer information on these concepts. All students benefited by using the software, some more than others. Students with a previously low level of electricity education benefited most, students with a previously medium level benefited less, and students with a previously high level benefited least.

Keywords: Computational Exploratory Environments, Modelling, Electricity, Engineering Higher Education

INTRODUCTION

During recent years there has been significant research work on exploratory learning (Bliss et al. 1992). There is also growth in the use of specific and powerful educational tools, such as HyperCard, and their evaluation (Kavogli 1993). The software:

1) allows us to merge different media – text, graphics, pictures, animation, sound and video – to improve learning & teaching of Physics concepts difficult to be perceived

2) helps students to build mental models and analogies in order to understand these concepts.

METHODOLOGICAL ISSUES

Research project

The research interest (Picciarelli et al. 1993) focused on how to activate adequate strategies to improve their learning, so that students can overcome their difficulties. Supplementary evidence for the research was also Brna's (1988) article on using computer-based exploratory learning environments. In this study, computer acts mainly as a tutor in the concept area of electricity in which students have learning difficulties. It also offers facilities such as animated pictures, calculations, graphics that are likely to produce faster or improved learning and to aid problem-solvng tasks with a required frequent amount of corrective feedback.

The software design is based on students' persistence of misunderstandings on models of current flow of electricity, voltage or potential difference, resistance, resistors in series and in parallel, and Ohm's law. Using the software students were put into conflict with their own models, and were encouraged to question their model, extending and modifying it as necessary (conceptual change), so that learning took place. Overall facilities provided by the software also acted as a kind of motivational feedback and affected positively learner & computer interaction (Watkings et al. 1995).

This is mainly a Questions/Exercise package which consists of three parts:

a) *Software Part 1 :* (Theoretical feedback on the above topics)

It provides another way of teaching & learning these concepts through models and analogies.

b) *Software Part 2 :* Ten questions with multiple choice responses and one exercise

Questions

To answer the questions users can have feedback provided by the software. Visual and sound effects are in progress in each interaction with the package as a motivational feedback.

Exercise

This is connected to a spreadsheet system that enables them to rapidly and easily make use of Microsoft EXCEL's database and graphics capability in Ohm's law.

c) The third part is an assessment of student's responses provided by the software. This is another feedback which affect learner & computer interaction, one of the principle aims of the software design.

Sample

The sample consisted of 30 University students who were in the first year and were taught the topic during their lectures in the Department of E & E Engineering and did some laboratory work in October. They have also passed the National exams. However, the sample is heterogeneous with reference to students' Physics backgrounds. Not only was an introductory session on HyperCard techniques and use of multimedia provided to them but a similar feedback was also offered by the software, as the basis for a better human-computer interaction.

Methods

Evaluation takes place in both human-computer interaction (technical domain) and learning of the specific topics of Electricity (subject domain).

Students' performance is studied by the Questions/Exercise tests to address the main directions of students' reasoning in three phases (pre-test : paper-and-pencil test at the end of October after the completion of the lectures on the subject domain, post-test on November, delayed-post test on March).

Their attitudes and the effectiveness of the software for learning electricity were also studied by a questionnaire administrated after they had completed all of their work with the software.

RESULTS FROM PRE, POST AND DELAYED-POST TESTS

Students answered ten multiple choice questions. They gave their own explanations on each one of them and did one exercise.

ANOVA-test was used to give means and level of significance for Questions (QTotPre, QTotPost, QTot Del), Explanations (ExpTotPre, ExpTotPost, ExpTotDel), and Exercises (ExerPre, ExerPost and ExerDel). Scheffe F-tests were applied between means to identify any significant effects of particular components. The data was also tested by using Wilcoxon test for verification and confirmation of the results of the research. There is no difference between the results from both tests.

For Questions QTotPre=the sum of the scores of the ten questions for every student in the Pre-test, QTotPost=the sum of the scores of the ten questions for every student in the Post-test, QTotDel=the sum of the scores of the ten questions for every student in the Delayed Post-test. The minimum score is zero and the maximum score is 60. There is a significant difference between QTotPre and QTotPost, QTotPre and QTotDel (p=0.0001). However, there is no significant difference between QTotPost and QTotDel. Thus, there is an increase of the means of scores from the QTotPre (42.1) to QTotPost (57.267) and QTotPre to QTotDel (56.5) (Scheffe F-test). There is also no significant difference of the means of scores between QTotPost and QTotDel.

For Explanations ExpTotPre=the sum of the means of scores for the explanations of the ten questions for the Pre-test, ExpTotPost=the sum of the means of scores for the explanations of the ten questions for the Post-test, ExpTotDel=the sum of the means of scores for the explanations of the ten questions for the Delayed Post-test. There is a significant difference between ExpTotPre and ExpTotPost, ExpTotPre and ExpTotDel (p=0.0001). Thus, there is an increase of the means of scores between ExpTotPre (36.333) to ExpTotPost (54.033), ExpTotPre (36.333) to ExpTotDel (49.867). There is also a small but significant decrease of the means of scores between ExpTotPost (54.033) to ExpTotDel (49.867).

For the "Exercise" which assessed students' use of a spreadsheet database and graphics capability, the scores were :

excellent	4	calculations+simple line graphs+comments on graphs+advanced calculations and graph drawing
good	3	calculations+simple line graphs+comments on graphs
fair	2	calculations+simple line graphs
poor	1	calculations
no	0	nothing done.

There is a significant difference between ExerPre and ExerPost, ExerPre and ExerDel, and ExerPost and ExerDel (p=0.0001). Thus, there is an increase of the means of the scores from ExerPre (1.233) to ExerPost (2.967) and from ExerPre to ExerDel (2.6). There is also a small but significant decrease of the means of scores between ExerPost (2.967) and ExerDel (2.6).

DISCUSSION

All students benefited by using the software, some more than others, because both the mean number of students and their performance on answering Questions, giving Explanations and doing Exercise increased.

Students' performance

Questions and Explanations

a) There was an increase of the mean number of the students' correct answers to the Questions and of their correct Explanations from Pre to Post and Delayed-post tests (increase 65% and 84%).

b) There was an increase of the mean scores of the students' correct answers to the Questions and of their correct Explanations from Pre to Post and Delayed-post tests (increase 40% and 52%).

Because the students' correct Explanations indicate proper learning – not just ticking an answer by chance or by guessing – the increases could be interpreted by the fact that the software had a positive influence on their understanding of the electrical concepts (Watkins et al.1995).

Exercise

a) There is an increase of the students' performance from Pre to Post and Delayed-post tests by using the spreadsheet.

Thus, 77% of the students did nothing up to calculations and simple line graphs in the Pre-test while 95% of them did calculations and simple line graphs up to advanced calculations and graph drawing in the Post and Delayed-post tests.

b) There is an increase of students' mean scores from Pre to Post and Delayed-post tests (mean increase from 1.733 up to 3).

Students' performance and their background knowledge in physics

Questions and Explanations

a) Students of the Low level benefited more (Stern 1987, McDermont 1984) because they had an increase on the mean scores of 76% and 99%.

b) Students of the Middle level benefited less because they had an increase on the mean scores of 31% and 35%.

c) Students of the High level benefited least because they had an increase on the mean scores of 14% and 22%.

Similar research findings were pointed out by other researchers (Watkins et al. 1995).

Exercise

Students of Low and Middle levels benefited more (mean scores increase 2) than students of High level (mean scores increase 1).

Thus, in Post and Delayed-post tests :

Students of Low level performed a fair use of the spreadsheet

Students of Middle level performed a good use of the spreadsheet

Students of High level performed an excellent use of the spreadsheet.

Similarly to van Zee and McDermont (1987) this agreed with students' comments in the Questionnaire in which 14 students claimed that they gained graphing skills (14 students = 2 High + 5 Middle + 7 Low level students).

Diagnosis of students' sequential reasoning

In the Pre test, the researcher/teacher diagnosed students' alternative frameworks while in the Post test students recognised their own errors by using the software and confronting their ideas. The change of their ideas came as a result of this conflict while using the provided facilities and discussing with the researcher/teacher and other students.

The model of current flow which is implied by the "before and after" error is called *the sequence model of reasoning* or *sequential reasoning*. If a change happens at a particular point in a circuit, then the current is influenced by a the change when it arrives at that point, but not before.

For example, the aim and objective of Question 1 were to diagnose students' alternative frameworks related to the brightness of a bulb and its location in a series circuit, while the aim and objective of Question 6 were the same but in more complicated circuits than of the Question 1. In the latter case, circuits included more than two resistors in series and a variety of locations of the bulb between resistors.

Two types of students' alternative frameworks were discovered :

In the first, there were 6 students who claimed that the brightness of the bulb was dependent only on the location of this bulb between the resistors of a circuit.

The second, there were 5 students who – although they took into account the Rtot of the resistors – supported that the brightness of the bulb was also dependent on the location of the bulb between resistors in the circuits.

Both are cases of sequential reasoning; the second one especially proves the students' persistence of misunderstandings on model of current's flow, pd, resistors and Ohm's law in series circuits. This can be assumed as another intermediate phase in the cognitive pathway until the system view model of reasoning to be conceived.

There was also 1 out of 30 students who had no model concerning the concepts of current, potential difference, resistance and energy in circuits with resistors in series.

Due to the every day language induced alternative frameworks, students misunderstood the flow of charge meaning of current with the flow of energy. So, they considered current as an "energy-like-entity" which was consumed in the bulb while changed into heat and light. Prior to the instructional software the students' explanatory system was in the form of simple linear causality in which the sole variable, which explained the brightness of the bulb and the wearing out of the battery, was current. The circuit was not regarded as a system where energy is transformed.

Finally, within the flow aspect of current introduced by the provided causal qualitative (macroscopic) models and analogies in both Questions, 12 out of 30 students (11 sequence model + 1 no model) adapted the system view of a circuit and they considered the role of current as a transporter of the electrical energy in a circuit.

Confrontation with students' ideas (post-test phase) and modification of their reasoning (post-test and delayed-post tests)

While using the software students were amazed when they found out that they had answered incorrectly (students' diagnosis of their errors).

Firstly, they reacted by refuting this fact because of the confrontation with their own notions concerning basic concepts of a circuit.

Secondly, they attempted to modify their reasoning and so they started to talk to each other and to the researcher. Then, they also used the provided facilities, the "Hints" and Software Part 1 (Theoretical feedback) buttons.

In all stacks the view of a circuit as an interactive system appeared and so the quantities of current, pd. and resistance co-existed and correlated.

The use of models helped them to regard the flow of current as a flow of electrons and also generated their own analogies in some cases.

The results from Post and Delayed-post tests proved that 12 out of 30 students might change their own to the scientific model of reasoning with the facilities provided by the software and their discussion with other students and the researcher/the teacher.

Skilfully led discussions appeared to be an effective vehicle for fostering dissonance, internal motivation and conceptual restructuring. In this approach students interact with the knowledge.

It should be important for students to be able to employ microscopic considerations by using the software and to achieve a more meaningful understanding than a mere manipulation of numbers or algebraic terms, as happened to Question 6 in which 5 students only stated the Rtot of the resistors and claimed that the brightness of the bulb was also dependent on its location between the resistors in the circuits.

The use of models and analogies in teaching & learning creates a cognitive anomaly for the learner and so offers opportunities for the learner to become active with the new ideas addressed by models and analogies.

Furthermore, it provides corrective feedback to get the learner to understand the relationships between the knowledge domain addressed by models and analogies. They facilitate learning and permit more memorable learning due to their greater imagery and concreteness. They also serve as a tool for cognitive economy by helping the transference of information in large chunks.

Students' learning was facilitated both through the mnemonic power of models and analogies and through the engagement in the analytical thought processes involved in metaphorical thinking. They were concerned with the discovery of relationships between the familiar and unknown domains and an exploration of the extent of which they could be related. As a result of that was the recognition and explicit formulation of both similarities and differences latent in the models and analogies.

The modelling framework of the software design was to stimulate concrete, causal explanations of abstract science concepts by making comparisons. Activities and discussion highlighted specific analogical relationships, e.g. between marbles and free electrons of metallic wires in the "Current in wires" stack. The well-known example of the snapping marbles for students to learn electric current is a very common and familiar game for them (Brown and Clement 1989). The software is trying to convey their feelings and experience from the relevant game about electric current. It is assumed that the context of the statements and the whole situation can guide learners to the intended interpretation of the statements in an efficient manner. Additionally, the use of the metaphor is likely to cause learners to make inferences beyond those statements which can be literally expressed, and hence a degree of affect may accompany the interpretation which would be lost if the software (or the teacher) simply listed the important features of current or just gave a description of the current flow (Ortony 1979).

This instruction encouraged students to associate familiar imagery about electric current with the unobservable events such as transference of energy through the free electrons of wires in a circuit, thus anchoring new concepts in a meaningful language. It could be considered as a motivation for students' reasoning within a microscopic level of thought. The fact came in agreement with Brown and Clement's (1989) research findings. These researchers also found that it is more accurate to call in some cases a microscopic model rather than a simple analogy.

Finally, if a teacher has carefully considered what students are to learn about a topic and what domains of knowledge students possess which can be used to reason analogically, then communication should be fairly efficient and the students' learning should be facilitated both through the mnemonic power of metaphor and through engagement in the analytical thought processes involved in metaphorical thinking.

RESULTS FROM QUESTIONNAIRE

Being referred to both technical and subject domains, 83% of the students claimed that the software environment was user-friendly with a simple operation which did not require any special knowledge or skills on computers. It was also enjoyable and introduced another way of reasoning which helped them to understand better the subject domain and therefore to consolidate their knowledge. They also mentioned that they gained computing skills on HyperCard and skills on drawing graphs through the provided spreadsheet.

DISCUSSION

Outcomes from the software use

63% of students claimed that they gained another way of reasoning about electricity concepts. 57% of them also claimed that they gained more understanding and clearer information on these concepts. Thus, they had learned the subjects better and they could explain them to others. 43% of students mentioned that they consolidated their knowledge on these electrical concepts, especially on topics such as circuits, resistors in series and in parallel etc. 40% of them also mentioned that they gained computing skills on HyperCard. 47% of students mentioned that they gained skills on drawing graphs through the spreadsheet. In this case, the total number of these students was 14 (2 High level background physics + 5 Medium + 7 Low) because of the fact that the use of the spreadsheet benefits students of low level background physics more, less students of medium level background physics and least students of high level background physics. It was interesting that :

1) Positive comments also came from students of high level background in physics [e.g. "The software helped me to refresh and consolidate electronic theory details in my mind.. it also helped me to realise a better way to solve a problem; so I gained another way of thinking..."(S1, H) "... I liked the combination of the unfamiliar knowledge to the familiar one...plus the discussion with the researcher helped me to gain another way of reasoning... and to draw inferences on the abstract concepts" (S2, H)].

2) Positive comments came from low level background in physics [e.g. "...an insight into another method of teaching, a better understanding of the basics of electronics because of the way of presenting these concepts linking the abstract to the concrete concept, for instance voltage dividers and animals model, resistance and hosepipe model..." (S3, L)].

Students' attitudes to the software

Generally, there was students' approval for the use of the software, such as "Good idea ! I enjoyed it!". They claimed that its environment was user-friendly and its operation was simple. They did not need to have special knowledge and skills on a computer. They obtained a full use of buttons, navigating through the stacks and exploring the information, especially in order to gain further details from theory to rectify their mistakes. They gained skills on HyperCard and drawing graphs. They did not mention any trouble in using the software.

73% of the students agreed that the software was enjoyable and motivated their interest. 57% of them emphasised on the advantage of the smart illustrations and animated pictures which introduced them to another way of reasoning and helped them to understand the electrical concepts easier by linking the unfamiliar and abstract information to the familiar and concrete one. Thus, they had fun with electricity and enjoyed a challenge in solving problems. They also emphasised the usefulness of the availability of the theory when needed. 67% of them expressed their willingness to spend more time for studying it (the theory) in detail. They also liked the alternative solutions of multiple choice answers, provided by the software. In general, the screen layout and the structure of the software stimulated their interest in going further.

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Development and Field Testing of a Thematic Module "Ionizing Radiation, Uses and Effects"– Creativity of 11th Grade Students

Michal Nachshon and Reuven Lazarowitz, Technion –ITT, Israel
Mutav@edu. Technion.ac.il

Ionizing radiation, a phenomenon originating in nature and from man-mademachines, affects our health and the quality of our lives. This radiation is utilized in various ways, such as medical diagnosis and treatment, agriculture, industry and research. Radiation is a process of the dissipation of energy or particles. Ionizing radiation causes the production of ions. This subject can be taught using a combination of a multidisciplinary-scientific base and the technological and social aspects of ionizing radiation. This approach is referred in scientific literature as: Science, Technology and Society (S.T.S). (Hofstein & Yager 1982; Yager, 1993). The educational aim of a multidisciplinary approach is the acquisition of knowledge and the ability to understand, in order to make informed decisions on social issues involving scientific and technological aspects.

The module "Ionizing Radiation, Uses and Effects" was written using a thematic approach combining scientific knowledge gathered from relevant fields – biology, chemistry, physics, technology and social aspects. It focuses on three levels:

1) The physical / chemical element: ionizing particulate radiation (alpha and beta), and electromagnetic ionization radiation (gamma and x-rays).

2) The effects of ionizing radiation on six organizational biological levels: molecule, organelle, cell, tissue, organ and organism.

3) The utilization of ionizing radiation in various areas such as medical diagnosis and treatment, agriculture, industry and research.

A combination of thematic teaching materials utilizing an STS approach, individual and cooperative learning forms a curriculum model. This model fosters scientific and technological literacy as well as higher cognitive skills (Lazarowitz, Hertz-Lazarowitz & Baird , 1994). It will serve the students as future citizens looking for work and functioning in a scientifically and technologically advanced society (Yager,1993).

Procedure

The research was carried out on three levels:

1) Development and writing of the module: "Ionizing Radiation: Uses and Effects" to the population of high-school students who do not opt to specialize in any of the science disciplines (biology, chemistry or physics) and the validation of its scientific content.

2) A formative evaluation of the module in a field-test, with the objective of testing the suitability of the learning materials. The field test was carried out amongst 52 high school students at a district school. Two Biology teachers taught the module in chemistry lessons. Furthermore, for 3 years the module was instructed by the researcher in high school students in the framework of elective courses.

3) Teaching the module to 29 high-school students to test learning of both thinking skills and scientific content knowledge.

The research combined normative and naturalistic research approaches.

The research questionnaires consisted of one scientific multidisciplinary knowledge questionnaire and five case study questionnaires which examined high cognitive thinking skills according to four parameters – problem identification, identification of information importance, question asking, and suggesting solutions (Yager & Tamir, 1993).These parameters were as follows:

Problem identification – students were asked to identify some problems in an article which they had read.

Identification of information importance- students were asked to identify the importance of the information from their point of view. This parameter was found more difficult than the other because of the required metacognition thinking.

Question asking – students were asked to ask as many relevant questions as they could on the information that they had read.

Suggesting solutions – Students suggested solutions to one of the problems that identified.

These parameters were examined in accordance to creativity characteristics: The ability to produce as many ideas as the student can *(fluency)* of different types *(flexibility)* and *originality* (Lazarowitz & Huppert, 1980).

Findings

In the answers of the pupils to the multidisciplinary questionnaire, expressions from high and low thinking levels were examined, which included concepts and principles that were studied in the learning of the module. In most of the expressions (25 out of 30) there were significant differences between pretest results (X=60.5; S.D =9.88) and the post-test results (X=84.6 S.D=4.51).

A possible explanation for the high achievements of the pupils in the module is the pupils' involvement in the studied topics. During the teaching the connection between science and day to day life was stressed, this way study topics became relevant to the pupils. The applicable aspect of the scientific content was presented to the pupil in a concrete way and created integrative content of scientific information applicable in society in fields of medicine, agriculture, research, and industry.

The combination of case study approach with teaching/ learning of multidisciplinary scientific topics enables the cultivation of high-level thinking skills. Students asked to answers five case study questionnaires which examine high cognitive thinking skills by four parameters — problem identification, identification of information importance, question asking, and suggesting solutions. It is possible to recognize a trend in the grade average of the students in the five case study questionnaires. The students grade averages on the fourth case study questionnaire (see table 1) were highest among all of the four parameters, whilst the grade averages on the fifth (see table 2) were lower than they were on the fourth case study questionnaire.

Table 1: Means and standard deviations of students' of "fourth case study" scores as related to characteristics of creativity

	Suggesting solutions	*Question asking importance*	*Identification of information*	*Problem identification*
General	(2.03) 6.31	(2.52) 6.81	(1.99) 3.81	(2.49) 6.23
Fluency	(1.11) 3.0	(1.43) 3.61	(1.16) 2.19	(1.06) 3.22
Flexibility	(67.) 2.45	(73.) 2.89	(00.) 2	(1.23) 2.77
Originality	(50.) 1.36	(63.) 1.2	(00.) 1.0	(00.) 1.0

Table 2: Means and standard deviations of students' of "fifth case study" scores as related to characteristics of creativity

	Suggesting solutions	*Question asking importance*	*Identification of information*	*Problem identification*
General	(2.5) 4.2	(1.62) 5.68	(1.95) 3.0	(1.42) 4.88
Fluency	(92.) 2.08	(76.) 2.8	(76.) 1.8	(58.) 2.58
Flexibility	(68.) 2.29	(65.) 2.52	(45.) 2.25	(51.) 2.47
Originality	(42.) 1.2	(00.) 1.0	(00.) 1.0	(00.) 1.0

It seems that we can identify a upwards trend in the characteristics of case study analysis up to the fourth questionnaire whilst on the fifth there is a noticeable downward trend in these grades. It is possible to explain this finding by the relevance of the case study subjects. The fourth case study dealt with the Chernobyl disaster. This subject bears relevance for the pupils and has importance due to the large quantity of media publications on the issue and due to the immigration wave from the former USSR On the other hand the fifth analyzed event dealt with the exposure of EL-AL pilots to Ionizing radiation from various sources, it is possible that this subject is not significant enough for the pupils and does not bear enough relevance for them.

From these explanations it is possible to learn of the importance of teaching/learning in connection with content knowledge relevant to pupils. Case study skills were examined according to creativity characteristics: fluency, flexibility, and originality. The creativity of the pupils is expressed mainly in the fluency and flexibility of their ideas as expressed by the number of response and differences categories under which they fell. Pupils improved the fluency and flexibility of their ideas during the experiment. As opposed to these factors (fluency and flexibility) the originality factor was low in most of the answers given by the pupils, and no great variations were found between the originality of the ideas in the five case study questionnaires.

From this information it appears that creativity is an acquired skill and originality is rare in learning activities expected from high-school students. During the study of the module students experienced various individual and co-operative instruction methods. Co-operative activities, when carried out in a suitable learning environment, contributed to the development of creativity.

The importance of this research is in the development of a teaching/learning method, which integrates the trying out of high thinking skills: case study approach and creativity with multidisciplinary scientific content knowledge. This approach is likely to increase public awareness for the future citizens using of thinking skills by focusing on student participation in problem solving and decision-making activities.

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Active Learning of Basic Thermochemistry Concepts

D. Sisovic and S. Bojovic, Faculty of Chemistry
University of Belgrade, Yugoslavia
dsisovic@helix.chem.bg.ac.yu
N. Sisovic, Faculty of Physics University of Belgrade, Yugoslavia
nikolas@ff.bg.ac.yu

Introduction

The prime idea behind the active participation of students in learning process is to get greater and more lasting output of education process and to realize it efficiently within scheduled term. Therefore, our recent efforts to revise learning of general chemistry in the first grade of general secondary school (age group: 15 years) were guided by several principles (Sisovic & Bojovic, 2000; Sisovic & Bojovic, 2001). It was assumed that students would be more likely to accomplish curricular objectives if

(i) they are engaged actively and thinking in class;

(ii) they construct the knowledge and draw conclusions themselves through laboratory work, that is designed upon their pre-knowledge, skills and everyday life experience;

(iii) they are encouraged to discover why certain concept is important for science literacy;

(iv) and in which way acquired knowledge can be applied in everyday life.

The process of acquiring and constructing the knowledge

(v) develops students' facilities of communication, collaboration, exchange of ideas and experiences, making decisions as well as responsibility for their own learning;

(vi) enables an advance of analytical and critical thinking, and

(vii) makes future citizens capable for critical attitude toward reality and less liable to trusting acceptance of information, which might be forced on them in their professional and every day life.

We find basic thermochemistry concepts appropriate for implementation of above stated principles.

The analysis of contents of physics and chemistry curricula in our country showed a lack of both terminology and time coordination (Sisovic & Sisovic, 2000). The concept of energy being studied for the first time in the elementary school – at the very end of the seventh grade physics course (age group: 13 years). The seventh grade physics introduces the concepts of kinetic, potential and internal energy as well as the law of conservation of energy. On the other hand, physical and chemical changes being taught within chemistry at the beginning of seventh grade. The students can observe during chemistry course that heating is needed in certain in-class demonstrations. However, an explanation is abridged to them, because the learning about exothermic and endothermic reactions is not planned by the elementary school chemistry curriculum.

Methodology

The research involved 179 students enrolled in the first grade of general secondary school. To evaluate effects of the active learning approach by pedagogical experiment with parallel groups, the sample is divided in control (87 students) and experimental (92 students) group.

An initial testing (Test 1) was performed in both groups. The classes in experimental group are additionally divided on seven groups. Each group is composed of 5 to 6 students, whose achievements at the initial test were different.

In accordance with the principles, we have prepared seven experimental tasks for in-group work. The students should have discovered the concepts of exothermic and endothermic reactions through laboratory work. Basic intention was to focus students' attention on fact that chemical changes are accompanied with energy changes. Therefore, changes of substance should be chosen in such a way to provide clear indication that chemical reaction occurs (gas released from system, precipitate, flame). Also, the energy changes during reactions should be apparent, either energy is released or absorbed.

Some of experiments required the thermometer readings, while another enable observation of physical or chemical changes that are occurred in the system in contact with the reaction vessel, where heating or cooling takes place. The list of experiments is given in the Table1.

Table 1. Experimental tasks for seven groups of students.

Groups	Chemical change of substance	Detection of energy change – triggered change of another substance
I	Reaction between hydrochloric acid and zinc	The temperature measurement by thermometer – expansion of mercury
II	Reaction between sulfuric acid and steel wool	The temperature measurement by thermometer – expansion of mercury
III	Burning of candle	Evaporation of water
IV	Burning of candle	Burning of sugar
V	Burning of alcohol	Decomposition of potassium permanganate

VI	Reaction between solution of magnesium sulfate and potassium carbonate	The temperature measurement by thermometer – contraction of mercury
VII	Burning of alcohol	The red color of the light emitted when lithium chloride crystals are placed into the flame

These experiments can help students to realize that

- the endothermic reactions could be spontaneous (reaction between solution of $MgSO_4$ and K_2CO_3), although most of them have to be driven by some external force (decomposition of $KMnO_4$); and
- exothermic reaction is not always instantaneous. Some of them must be supplied with the certain amount of energy (energy of activation) before it will begin.

Each group is supplied with a worksheet, which determined an experimental task, the necessary equipment and substances. The questions within the worksheets aimed to lead the students to analyze the experimental results, to give explanations and draw conclusions.

Having finished their experiments the groups prepared written reports. Then the group spokesmen read their reports to the members of other groups, while a member of a respective group would write down the equations of chemical reactions and data obtained in experiment on the blackboard. The blackboard enabled visual presentation of main findings of all groups. Students were encouraged to inquire each spokesman after his/her presentation and to discuss extensively.

Different experimental tasks for in-group work managed very fruitful discussion, because each group, as an expert for certain situation (example), has contributed to the construction of the concepts of exothermic and endothermic chemical reactions. For example, in order to underline the practical significance of energy and its resources, an analogy could be made with the results of the third group: it is known that coal burns in highly exothermic reaction and the heat released is often used to convert water to steam that can turn turbine to produce electricity.

Control and experimental group are examined by final test (Test 2).

In order to check the retention of knowledge, two mounts later we performed scrutiny by Test 3.

Results and discussion

It is interesting to note that at the Test 1 the control group (59.1%) achieved 5% higher overall result than the experimental group (54.4%) and the homogeneity of control group results was higher, too.

At the final test (Test 2) the experimental group (74.5%) achieved 2% higher overall result than the control group (72.4%). The difference between percentage of the correct answers is not statistically significant.

At the Test 3 (retention) the percentage of correct answers was 64.1% in experimental and 48.3% in the control group. The difference between percentage of the correct answers, evaluated by the t-test (t=2.17), is statistically significant on the level of 0.05.

Conclusion

The obtained results support described approach, and show that the teaching process should be organized in such a way to stimulate active participation and independent acquisition of knowledge. The applied approach was particularly fruitful at the level of understanding.

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Why Be a Science Teacher?

Susan Barker and Pilar Reyes
University of Warwick, Coventry, UK
s.barker@warwick.ac.uk

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INTRODUCTION

Teacher recruitment world-wide is currently a serious problem with science teachers particularly difficult to enlist. Whilst recruitment to the teaching profession does fluctuate on an annual basis and is linked directly with the job market, there has been a general trend downwards of numbers entering science teaching in recent years in the UK. This problem is likely to be exacerbated by the declining numbers of students taking up science at degree level and choosing science options in the school curriculum. Having motivated and enthusiastic science teachers who will engage youngsters in the discipline must be a priority in preparing our future citizens. During the 1990s recruitment for postgraduate teacher education courses in the UK in secondary teacher training, was on average 17% lower than the expected target with the subjects of maths and science facing serious recruitment problems. In 1998/99 there was severe under-recruitment in science (25% under) and although the 'under-target' figures are improving this is partly to do with the reduction in targets from 1997–2000. (DfEE and TTA 1999)

In order to address these difficulties the British government, since 1998 has provided financial incentives in terms of bursaries for students training in shortage subject areas (including Maths and Science) and from 2000 this money is in the form of training salaries for student teachers. From September 2000 the £70m package is being spent as a '*Golden hellos*', for those who enter teaching in Maths, Science, Modern Languages and Technology. It remains to be seen whether these Golden Hellos are sufficient to remedy the situation although early indications suggest that recruitment to teacher training course has in fact increased. The Graduate Teacher Training Registry (GTTR), a central agency which acts on behalf of universities, colleges of higher education and certain groups of schools in England and Wales process applications for entry to their pre-service Postgraduate Certificate in Education (PGCE) courses. Their data suggests that in December 2000:

- biology applications were up 18.8% ;
- chemistry applications were up 33.7% ;
- physics applications were slightly down. (GTTR 2001)

They attribute such increases directly to the training salaries but also the significant marketing campaign using newspaper and television advertisements with the key slogan *'no one forgets a good teacher'*. However they do not account for the lack of any increase in physics applications.

Aim

The aim of this research is to identify key factors and reasons why people choose secondary science teaching as a career. It also aims to evaluate current UK marketing strategies for the teaching profession.

Objectives of the research

- identify the key reasons for being a secondary science school teacher;
- assess the reliability of reasons given on application forms for teacher training courses;
- evaluate current marketing strategies for teaching as a career;
- make recommendations for future science teacher recruitment.

Methodology

The data for this study were collected through content analysis of three sources of information plus an anonymous questionnaire, all from one Higher Education Institution. All student data were collected with permission from the students on the basis of agreed anonymity. The methods employed were:

- content analysis of GTTR (Graduate Teacher Training Registry) application forms for secondary science teaching (3 years n=100)
- anonymous questionnaire (2 years n=70);
- individual interviews (n=11);
- evaluation of Teacher Training Agency marketing materials.

1. GTTR FORMS

Permission was sought from trainees to analyse their GTTR application forms. Part of the form specifically requests information on why the applicant wants to teach. It was this section that was analysed using content analysis. It was carried out on 100 GTTR application forms from one Higher Education Institution for intake years of 1997/98, 1998/99, and 1999/00. Coding categories and units of analysis were identified through a preliminary review of the forms. The criteria used in selecting data for generating categories were the data itself. The data were selected in terms of what was significant to the research questions. Each reason given on the form was classified as "belonging or not belonging' to a particular group. During the process of developing categories, revisiting categories and data was crucial (see Dey 1993). The units of analysis were identified directly from the coding categories. Table 1 presents the reasons given grouped by the units of analysis.

Table 1: Units of Analysis for reasons for entering secondary science teaching recorded on GTTR forms.

Category	Unit of analysis
A	Subject
B	Personal qualities and skills
C	Professional concept of teaching
D	Intuitive feeling about teaching
E	Social interaction with people
F	Helping and sharing- altruism.

A coding frame was developed using these units and the reasons given by students on their GTTR were recorded in this frame.

2. Questionnaire. The questions/statements were framed after analysis of the reasons given on GTTR forms. They directly relate to the overall research questions and are as follows:

Table 2: Questionnaire Questions and Statements

I enjoy interacting with children.	I believe I have the right skills for teaching.
I wish to share my enthusiasm and knowledge.	
Teaching enables me to continue working in my subject area.	From a very early age I have always wanted to teach.
Teaching has a good career structure.	The teaching profession is rewarding career.
I believe I have a lot to offer by helping others to grow and learn.	There are not many jobs for graduate scientists but in teaching there are lots of jobs
I believe I would be a good teacher.	I enjoy working with young people.
I have the right personal qualities to be a teacher.	I cannot think of anything else to do
I enjoy my subject area very much	The holidays are good

The respondents were given the following instructions for completing the questionnaire:

The following is a set of statements about some views on going into teaching.

'For each statement please say whether is very important, important, neutral, not important, absolutely not important to you. Tick the appropriate box.'

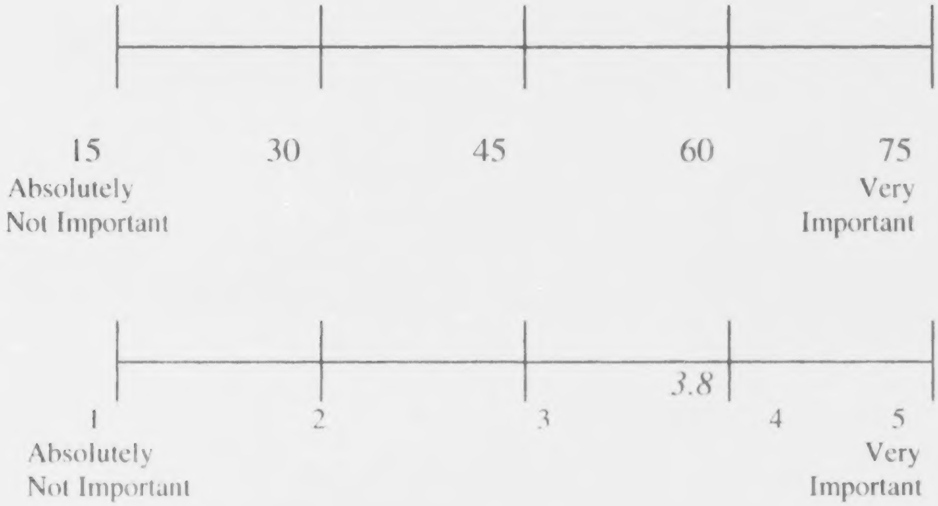
The boxes were arranged according a Likert type scale(Likert 1932) shown below:

Very Important	**Important**	**Neutral**	**Not Important**	**Absolutely not important**

The questionnaire was completed anonymously by students beginning their science teacher training course. After assigning numerical values (between 1–5) to the possible responses, a score for each individual was determined by calculating the sum of the numerical values of the alternatives checked. (Likert, 1932). The matrix was calculated using EXCEL Spreadsheet. Once the total score for each of student's answers was determined, the average was calculated with a very simple formula of the division of the total score of the students' answer by the total of lowest score of the statement given (15 points). Then the score is analysed within 1 to 5 points as follow:

For example, a student with a scores of 58 points in total, the sum is divided by 15 points and the result is 3.8 points. The student's reasons for going into teaching are highly relevant in his/her life.

Figure 1: Range of summated rates for Questionnaire about reason for going into teaching.



3. Interview. The interview questions directly relate to the overall aim of the research. All eleven interviews were recorded on tape and then transcribed. The interviewees all volunteered to be interviewed and were selected on that basis.

Table 3: Interview methodology and questions.

Sequence	Aims	Questions
Main body	To find out reasons why students want to enter the science teaching profession.	Why did you decide to come into the teaching profession to teach science?
Cool-off	To assess reliability of reasons given.	What would you say about the teaching profession to a friend who is not sure about going into teaching?

Results

1. GTTR forms The data from the forms are presented in Tables 4, 5 and 6 .

The majority of students indicated on their application forms that the main reason why they would like to be science teachers is that they want to continue working with their specialist subject (59%), that they have the personal attributes and skills for entering teaching (52%). and a love of children (53%).

Table 4: Reasons given on GTTR forms for entering secondary science teaching grouped by category.

Unit of analysis	% n=100	Summary	Examples
Subject	59	Teaching as a way of working with subiect matter (Chemistry, Physics or Biology)	'my own passion for science provides my motivation to teach this diverse and complex subject matter'
Qualities and Skills	52	Teaching as related to variety of personal qualities and skills.	'I have good communication and presentation skills and I enjoy making presentations to students'
Concept of Education	22	Teaching as stimulating, challenging and rewarding profession.	'I believe it will offer me the challenge I want from a job'
Feeling about teaching	35	Teaching as a feeling of something to offer, helping in growing and learning.	'I have always wanted to teach'
Work with people	53	Teaching as interaction and love of children/young people.	'I love working with children'
Help and Share	40	Teaching as a contribution to child development.	'I would like to help children to enjoy the learning experience and give them confidence in themselves'

Table 5 : GTTR Reasons for entering science teaching by GENDER

	Female % (n= 59)	**Male** % (n=41)
Subject	64	51
Personal qualities and Skills	56	46
Professional concept of teaching	27	15
Intuitive feeling about teaching	32	39
Social interaction and love of children	56	49
Help and share	46	32

Table 6: GTTR reasons by subject and gender SUBJECT

Gender	**Female**			**Male**		
	Biol **%** **n=39**	**Chem** **%** **n=14**	**Phys** **%** **n=6**	Biol % n=25	Chem % n=9	Phys % n=7
Subject	**64**	**50**	**100**	60	11	71
Personal qualities and Skills	**64**	**29**	**66**	36	88	29
Concept of teaching	**26**	**36**	**17**	8	44	0
Intuitive feeling about teaching	**36**	**29**	**17**	52	22	14
Social interaction and love of children	**69**	**29**	**33**	56	33	43
Help and share	**51**	**29**	**50**	24	44	43

It seems that Physicists are most likely to give the subject reason than any other and Biology females are most likely to want to enter science teaching because of a love of chidden. Physics males are least likely to like children! Male chemists strongly indicate the skills aspects of teaching whereas female chemists and physicists are least likely to mention skills. Age aspects were analysed but the data not presented here because older students are fewer but observations form the data indicate that older females are more likely to want to teach as a result of a desire to work with children and a desire to help and share than anything else. There was also a similar general tendency with males but this was less pronounced; it seems the older you get, the more you wish to work with children.

3. QUESTIONNAIRE.

The overall range of the scale is from 15 to 75 with the high scores indicating those students having very important reasons to going into teaching and the low score few important reasons for going into teaching. The summated mean scores are presented in Table 7.

Table 7: Mean Summated Likert scores from questionnaires

Mean summated Likert scores	98/99	99/2000
Total	56.4	55.8
Female	56.5	56.2
Male	56.5	54.8
Biologists	57.1	55.7
Chemists	55.5	59.8
Physicists	55.8	50.7

Although statistical analysis is not yet complete it is clear that there is little difference in the importance of reasons for entering teaching with gender and subject. However the reasons given by female biologists are slightly more important to them than other categories of trainee teachers.

3. INTERVIEW

In individual interviews, other reasons which had not been eluded to through GTTR forms or questionnaire, were factors such as job security and geographical location and these were deemed important. When asked "*why did you decide to come into the teaching profession?*" The following reasons were given within the units of analysis being used in the research.

Table 8 :Example quotations from interviews grouped by units of analysis

Unit of Analysis	Example Quotations from interviews
Subject (100 % of respondents)	I enjoy and have a great interest in science. I have done it for so long. Ehhhm, for me really ,it was just ehm studying the subject area. I have always enjoyed passing on information. I always like the subject knowledge, you know working with, hopefully inspiring people, and they get more active in their education I suppose. When I was looking for a career change I still wanted to work with sciences , so I thought the enthusiasm that I have got I can bring it into a teaching
Qualities and Skills (45% of respondents)	I like talking.
Concept of Education (45% of respondents)	Ahm, I think it is a profession where you are giving and getting a lot of reward from it, I suppose
Feeling about teach ing (100% of respondents)	I have always wanted to teach Amh , I don't know it is something that I have always wanted to do.
Work with people (64% of respondents)	I have done quite a lot work with young people, and I generally love it. I like working with children, that is the main reason I want to do it.
Help and Share (64% of respondents)	I was doing my degree, I did a module in counselling in which I had to go into a local school and help for ten weeks, ten mornings sessions, and basically I went to school , observed the classes, and if people need any helped I tried. I have always liked sort of explaining thing to people

Other reasons which were given which did not fit into the coding categories or units were:

"I want to stay local hopefully because I have family now"

"Maybe its a silly reason probably to some people but I would like a job locally, and not to have to leave the family or anything, because I more family orientated ,so I couldn't imagine going into London to get a job or something"

"I have been looking for a job with stability and teaching does offers that"

These additional reasons were classified as job security and locality (geographical preference). In addition many students used the rewards from prior teaching experience as the stimulus to enter teaching profession e.g.

'I have done quite a lot work in school, I done more probably key stage 2 but sort of experience but then I went to key stage 3 and 4 so knew that was what I wanted to do I wanted to go to secondary'.

4. CURRENT MARKETING STRATEGIES

The advertising campaign is based on new slogan '*No one forgets a good teacher*'. Their brochure start with the following statement :

" Teaching is a challenging and rewarding profession. It demands the highest intellectual, analytical and communication skills. Teachers also need commitment, understanding and the imagination to inspire young minds. If you can meet this challenge, no other profession can give you the opportunity to make such a difference to so many young people's lives". (TTA 1999)

The booklet emphasises working with a specific subject area e.g. geography, skills and feeling of offering something to society. In addition job satisfaction and financial incentives are given great emphasis. The materials are not specific to science but the reasons given by the teachers appearing in the materials fit in well with the categories previously outlined. (Table 9)

Table 9: Content Analysis of teacher Training Materials- reasons given by cameo teachers

Unit of Analysis	Examples of teacher statements
Subject	"I entered to teaching profession because I have always enjoyed studying Geography and wanted a challenging career where I could use this Geography on daily basis"
Qualities and Skills	"To be a good teacher, you need a willingness to understand the student's position, effective organisation skills, and enthusiasm" "Excellent teachers will ensure that students have the opportunity to reach their full potential and fulfil their dreams" "It is important to have a sense of humour with pupils, interacting with them and gaining their respect. This is a career I am glad to have chosen" "New technology presents exciting new challenges to schools. Tools such as the internet and CD ROMs provide students with the opportunity to use resources and communicate with people from the whole world".

Concept of Education	"Education is constantly evolving; it is bound to have changed since you were at school yourself. There is a lot more to it than it seem as a pupil". "The majority of students recognise the importance of education, and I think society as a whole will re-assess, how it values teachers".
Feeling about teaching	"If you want a career that offers challenge, job satisfaction and opportunity- teaching is it".
Work with people	The interaction between teacher and student keeps you alert and alive. Every day is different and brings new challenges" "I became a teacher because I wanted to work with children, to open up ideas in their minds which lead to a desire for life-long learning".
Help and Share	There is immense satisfaction in knowing that you have helped pupils to achieve something whether it is an 18 year-old coping with A-level coursework or a year 7 pupil learning how to subtract two numbers without a calculator."

The teachers who feature as cameos can be described as follows:

Table 10 : Description of teachers features in 'No one forgets a good teacher' (TTA 1999)

	Approximate age			Ethnic Origin		
	Young under 25 years	Middle 25-35 years	Mature 35+ years	White	Black	Other
Male	7			5	2	
Female	9	1		9		1

The marketing materials as described in Table 10 are very much aimed at young newly qualified graduates. The new marketing materials for 2001 do not feature any cameos of teachers but relies heavily on abstract photographs. The booklet uses a slogan of " *Can you light a fire?*" " *Those who can, teach*"

DISCUSSION

The desire to be a science teacher is obviously based on a complex range of issues and determining the most important reasons and their determinant factors is difficult. The results obtained in this survey concur with other work in this field, with job satisfaction and working with children the most important factors and sharing of knowledge and contributing to child development also important (Stewart and Perrin (1989) and Reid and Cauldwell (1997). Stewart and Perrin (1989) and Reid and Cauldwell (1997) also highlight being inspired by their own teachers as a common reason for entering teaching, Certainly in this study of science students inspiration was never mentioned as a reason. There is a mis-match of reasons when application forms and questionnaires are analysed. It is suggested that application forms for entering teacher training courses are not reliable in determining the real reasons for an individual pursuing science teaching as a career. Many applicants are clearly writing reasons in their course applications which they feel the selectors wish to hear. Indeed in anonymous questionnaire it seems that a small number of applicants are getting onto teacher training courses who are not truly dedicated to the profession having indicated that there was '*nothing else to do*'. Apart from wanting to work with the specialist science subject most of the reasons given for entering science teaching are generic and not specific to science. The marketing strategies employed by the Teacher Training Agency do include reasons which correlate closely with the reasons given by applicants, although job security and working in specific geographical locations are not used. Furthermore ' *having nothing else to do*' is also not employed despite it being a real reason given for entering teaching. The use of such statements could seriously damage the already low status that teachers have in the UK. The portrayal of young teachers of a mixed ethnic background is positive although could deter older candidates who have been shown by this research to demonstrate valid and important reasons for entering teaching.

It is recommended that in future, marketing and recruitment strategies should include the added value criteria identified in this research. In addition, further research is needed in order to ensure that individuals with excellent potential as science teachers do enter the profession and those who are least committed gain employment elsewhere. Increasing reliance is now being placed on training older people who enter from other occupations

(Spear, Gold and Lee 2000). Indeed this research would suggest that many of these older candidates wish to teach because of a genuine love of children and their subject-what more could we ask for!

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How Do Sixth-Grade Students Reason in Science?

Nicos Valanides and Maria Papageorgiou
University of Cyprus, Cyprus
nichri@ucy.ac.cy

AIMS AND SIGNIFICANCE

The development of scientific thinking skills has been the goal of many reform efforts in science education during the last decade. According to Klahr and Dunbar (1988), scientific thinking is developed when students are engaged in problem-solving situations in which they reason scientifically to form and test hypotheses. In particular, Klahr and Dunbar's proposed model of *scientific discovery as dual search* has been influential for science education researchers and cognitive psychologists. Specifically, Klahr and Dunbar argue that scientific discovery is a cognitive process during which (a) hypotheses are formed, and (b) hypotheses are refuted or verified through scientific experimentation and investigation.

Report after report issued by educational agencies (e.g., National Center for Education Statistics, 1998) indicated that teacher-centered instructional environments failed to promote thinking in the classroom. Hence, the challenge for instructional designers and curriculum developers has been how to design learning environments in order to foster and promote thinking and problem-solving skills (e.g., Gott & Duggan, 1995, 1996; Westbrook & Rogers, 1994). Current trends in science teaching (e.g., Roth & Roychoudhury, 1993; Lavoie, 1999; Gunstone, 2000; Doyle, 2000) aim at designing and developing inquiry-oriented learning environments in which learners practice science process skills such as: (a) defining a scientific problem, (b) forming hypotheses, (c) designing experiments, (d) observing and collecting data, (e) analyzing and interpreting data, and (f) applying the results to refute or verify initial hypotheses.

In virtue of recognizing the need for reforming science education in Cyprus as well, we conducted the present study in order to examine the extent to which students in Cyprus have their science process skills developed. Therefore, we consider the results of this study important, as they may provide us with evidence and justification about the need to reform science teaching in Cyprus schools.

METHODOLOGY

Description of the experimental setting

A device was used to elicit students' reasoning skills. The device was a wooden white box with eight colored light bulbs, five switches, and a pushdown button that was used to test the result of an experiment. The eight light bulbs were lined across the top of the box surface, the switches across the middle, and the pushdown button was located at the bottom in the middle. All bulbs and all switches were numbered. In addition, next to each switch the positions "down" and "up" were marked appropriately. Switch number 3 constituted the general switch of the device and switch number 5 was not connected to the electric circuit of the device at all. A bulb could light up only when the general switch was first placed in the down position and any of the other switches were turned on.

Sample

The sample consisted of 11 sixth-grade students who were attending an elementary school in Cyprus. Specifically, there were six males and five females that participated in the study.

Data Collection

Data were collected with 11 clinical interviews, one for each research participant. Each interview lasted between 40 to 60 minutes, was tape-recorded, and transcribed for data analysis. Prior to the 11 interviews, one pilot interview took place to try out the research procedures.

Research Procedures

When students came to the research sessions were first presented with a simplified version of the electrical device, to familiarize them with the experimental setting. The simplified version consisted only of one light bulb, one switch, and a pushdown button. After the presentation of this device students were asked to formulate a hypothesis about how the bulb would light up. Then, students were presented with the actual device and were asked to form hypotheses about how the circuit worked. Subsequently, they were asked to carry out experiments using the device in order to prove or disprove their initial hypotheses.

Results

Succinctly, when students were presented with the simplified version of the device, eight of them correctly hypothesized that the light bulb would light up by moving the switch in the upward or downward position followed by a hit of the pushdown button. Three children said that the light bulb would light up by either moving the switch upwards or downwards or by hitting the pushdown button.

When students were presented with the actual experimental device, they were able to generalize from the simpler device to the more complicated mechanism of the experimental device. After a series of experiments, 10 out of 11 children managed to discover the function of switch number 3, and all children discovered the function of switch number 5. Additionally, all children managed to discover which combinations of switches lit up a bulb. Lastly, nine students believed that the down position of the switches indicated that the circuit was closed. In sum, students formulated 25 to 45 hypotheses and carried out 25 to 50 experiments. In the sections that follow, we discuss in more depth students' reasoning during their investigations with the actual experimental device.

Children's initial hypotheses

Table 1 below presents children's initial hypotheses prior to experimenting with the device.

Hypotheses	Frequencies	Participant ID
All bulbs could light up	7	C_1[1], C_2, C_4, C_7, C_8, C_9, C_{10}
Only five bulbs could light up	4	C_3, C_5, C_6, C_{11}
The bulbs light up:		
When different switches are used in combination	3	C_1, C_7, C_{10}
When only one switch is used at a time	8	C_2, C_3, C_4, C_5, C_6, C_8, C_9, C_{11}
Each bulb lights up separately	4	C_3, C_5, C_6, C_9
Multiple bulbs can be lit up simultaneously	7	C_1, C_2, C_4, C_7, C_8, C_{10}, C_{11}

Table 1. Children's initial hypotheses

As shown in Table 1, seven children indicated that all eight bulbs could light up. Four children supported the view that only five of the eight bulbs could light up, and two of the four children specified that these bulbs would be bulbs numbered 1 to 5. Three students suggested that a light bulb could be lit up by using a combination of switches. The other eight children argued that a bulb could be lit up with one switch only. Specifically, students thought that switch number 1 lights up bulb number 1, switch number 2 lights up bulb number 2, and so on. Furthermore, only four children hypothesized that one bulb only could be lit up at a time. The other seven children stated that multiple bulbs could be lit up simultaneously, and two of these seven children argued that it was impossible to have only one bulb lit up.

Children's experimental investigations and new hypotheses

After forming their initial hypotheses, students were asked to carry out experiments in order to test their hypotheses. Once they started their investigations using the device, it was evident that some of their initial hypotheses were false. Nonetheless, children did not use the experimental evidence to understand and explain why the data falsified their hypotheses. Instead, some of them kept on believing that their initial hypotheses were correct, whereas some others were more willing to formulate new hypotheses that they justified with different reasons. Table 2 summarizes all reasons participants gave to explain their new hypotheses.

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[1] C_1,C_2, C_3 …C_{11} are used as pseudonyms.

Table 2. How children justified their new hypotheses

Children's reasoning was based on:	Frequencies	Participant ID
Math	7	C_1, C_2, C_4, C_5, C_6, C_9, C_{10}
Physical position of switches and bulbs	4	C_6, C_8, C_9, C_{11}
Outcome of previous experiment	6	C_1, C_3, C_4, C_5, C_6, C_8
The number of switches placed in the "down" position	4	C_2, C_6, C_8, C_9
The position of the last switch manipulated	3	C_2, C_3, C_6

As shown in Table 2, seven children believed that the position of the switch was a key factor in determining which bulb would light up. For example, four children argued that by moving switch number 1 to the down position, it would light up bulb number 8 because switch number 1 was the first switch and bulb number 8 the last bulb. In addition, seven children believed that if for example switches 2 and 4 were placed in the down position then bulb number 6 would light up because 2+4=6. Moreover, six children used the results of their previous experiment to predict which bulb would light up next. For example, if bulb number 2 was lit up then bulb number 3 had to be the next bulb to light up. Four other children stated that the number of switches placed in the down position determined which bulb would light up. For example, if four switches were put in the down position then that meant that bulb number 4 would light up. Lastly, three participants thought that the position of the last switch manipulated by them determined which bulb would light up. For example, if switch number 2 was the last one to be used then bulb number 2 would light up.

Children's experimental investigations and revised hypotheses

When students were asked to predict if multiple bulbs could light up simultaneously, initially, seven students argued that multiple bulbs could light up at the same time, and four students stated that only one bulb could be lighted at a time. After experimenting with the device, as shown in Table 3 the majority of students were able to use data to support or refute their initial hypotheses.

Table 3. Using evidence to reject or accept initial hypothesis

Initial hypothesis	Participant ID	Hypothesis supported during the interview	Hypothesis supported at the end of the interview
One bulb could be lit up at a time	C_3, C_5, C_6, C_9	C_6	C_1, C_2, C_3, C_4, C_5, C_6, C_7, C_8, C_9, C_{11}
Multiple bulbs could be lit up at the same time	C_1, C_2, C_4, C_7, C_8, C_{10}, C_{11}	C_1, C_2, C_3, C_4, C_5, C_7, C_8, C_9, C_{10}, C_{11}	C_{10}

Particularly, as shown in Table 3, three participants who gave correct initial hypotheses rejected them during the interview even though experimental results did not contradict their initial hypotheses. Moreover, seven children who held false initial hypotheses did not reject them during the experiment even though there were data for rejecting them. Gradually, after carrying out more experiments, 10 out of 11 students formulated the correct hypotheses.

Children's reasoning about the general switch

Elsewhere in this paper, we mentioned that 10 out of 11 children were able to figure out that switch number 3 was the general switch of the device. Nonetheless, only four children managed to solve the problem without any help from the researcher. The researcher helped the participants by asking them several questions such as "When do you believe the bulbs light up?" and "Are there any cases that they don't light up?" Moreover, the researcher encouraged the students to write down their observations as they were carrying out their experiments. Gradually, after collecting enough data they figured out that switch number 3 was the general switch even though no one named it as such. They described it as "main switch" or "important switch," and almost all of them said that "the bulbs light up when switch number 3 is placed in the 'down' position."

Children's reasoning about the unconnected switch

All eleven children discovered that switch number 5 functioned in a quite different way in comparison with the rest. Students who were able to figure out the problem by themselves managed to solve it by observing that some combinations of switches caused the same bulb to light up twice. Eight participants received some help from the researcher in the form of questions such as "When does a bulb light up twice?" and "Will all bulbs light up twice?" Four children described switch number 5 as "redundant switch," "invisible switch," and "unconnected switch." The remaining seven children stated that switch number 5 was very important and they supported it by saying "it's connected with many wires," or "it can make the bulbs light up twice," or "if it wasn't here no bulb could light up twice, hence it is very important." But, the majority did not spell out explicitly that it was not connected to the circuit.

DISCUSSION

Based on the research findings, the majority of students were able to figure out the functions of switches 3 and 5 after carrying out many experiments and forming many hypotheses prior to solving the problem. Thus, based on these results, it seems that Klahr and Dunbar's (1989) theory that all children problem-solve in the experiment space rather than in the hypothesis space, has validity. In other words, children solved the problem by looking at the data they were collecting and not by using their hypotheses. As a matter of fact, children did not even modify their hypotheses according to the experimental data. During their experimental investigations students did not try to understand cause and effect relations since their thinking was superficial and often depended on the surface features of the device. They were mostly interested in making a desired outcome occur or reoccur no matter if there was no logic behind their reasoning. In addition, students were more interested in the successful results they obtained and ignored the unsuccessful ones. Therefore, even though children used the experimental results to solve the problem, they failed to understand the problem holistically.

Moreover, some of children's hypotheses and reasoning seemed at times irrational. For example, their hypotheses that the sequence of carrying out the experiments influenced the experimental results, that the position of the bulbs and the switches determined which bulb would light up, and that by repeating the same experiments different results could be obtained seemed peculiar and odd. On the other hand, some other hypotheses, children formed, were influenced by their everyday experience. For example, some children argued that only one switch could light up a bulb and that a switch had to be moved from the "up" position to the "down" position to turn on a bulb. It was obvious that children were relating their everyday life experiences to the experimental investigations and they were using their preexisting knowledge to make sense of the experimental setting.

Another finding that was also surprising was the fact that even though children collected data that contradicted their hypotheses they did not reject them. Along the same line of reasoning, students were not arguing reliably since they often responded differently when the same situation was presented to them at different times. Also in some cases, while students refuted a hypothesis based on experimental evidence, they later supported it again.

In conclusion, based on the results of this study we recommend changes in both the curriculum and teaching practices. The curriculum has to be redesigned so students have more opportunities to engage in the scientific reasoning process. Moreover, instructional environments for science teaching and learning should be authentic so students learn to think the way scientists think. In addition, students need to be given interesting and motivating problems to solve, and these problems should be relevant to learners' lives. Learning science in school should not be divorced from using science out of school. Teachers should teach learners how to argue with reason and evidence, and they should scaffold students' learning by asking them questions that gradually students must learn to be asking themselves.

The issue at hand now that we would like to further study is how learners' thinking is developed in activity contexts that are not designed to allow learners to engage in trial and error problem solving. The results of this study indicated that the sixth-grade students who participated in the study were more experimenters than thinkers – that is students failed to reason reliably based on their initial hypotheses and evidence. How do we design activity contexts that minimize trial and error problem solving and what would be the effects on students' motivation, thinking, and quality of reasoning?

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The Interaction of Teacher and Pupil in the Classroom

Iveta Līce, Latvia University of Agriculture, Latvia

ivetal@cs.llu.lv

Abstract. Learning is a creative process of acquiring knowledge. It depends on many factors. A teacher and a pupil are very closely connected in learning activity. On of the aspects of successful teaching is teacher's and pupil's interaction. The purpose of this study is to investigate the interactions between pupils and teacher in the lesson. Observations were conducted with 320 pupils of 5th and 6th grade and 130 teachers from elementary school. The major findings were: the teacher mostly used interaction with whole class (52%), but the pupils didn't like it. The pupils understand the study material better when group interaction form (46%) is used. Individual interaction form (31%) is not so appreciated. It makes us think about exchanging teaching methods.

Key words: Interactions – the whole class, a group of children, individual. Management. Authority.

Introduction. Learning process is both the processes of intellectual and mental development of pupil and the process of education. Obtaining knowledge and teaching of different action types have to take place simultaneously with intellectual, moral, aesthetic, political, and physical education of personality.

Learning and education are closely interrelated. Under certain conditions learning influences the level of education; on the other hand the level of education influences studies. The more effective is learning process; the higher is the quality of knowledge obtained.

Learning and education is a combined process where students obtain knowledge, skills, experience of creative action, and it stimulates the mental development of the personality.

Learning is a creative process of acquiring knowledge. It depends on the following factors:

- what is taught;
- who is teaching;
- how is it taught;
- who is taught

All these factors – the Theme, Teacher and Pupil – are very closely connected. They don't exclude each other but on the contrary interact mutually and form the necessity for further collaboration. The teacher and the pupil active by collaborate in interaction process and influence each other in classroom.

Nowadays the political and economical changes have influenced the school model and have caused changes in teaching methods and relationship at school. They change towards democratic and equal society model.

The interaction between teachers and pupils is fundamental for several reasons. First, thanks to the activity of teaching and secondly to the organisation and management of classroom. The relationship between teacher and pupils needs to be based on some qualities out of which two are very important and necessary. The first of these is the pupils' acceptance of the teacher's authority. The second quality is mutual respect between the teacher and pupils. The teacher's main task is to organise and manage pupils' learning. This involves control over both the management of learning activities and the management of pupils' behaviour.

The learning process greatly depends on specific forms of interaction: whether the teacher directs his interaction to the whole class, to a group of children or to individual. These interactions are central to classroom life and aim of education both from the teachers' and the pupils' points of view. All specific forms of interaction are very important and necessary for learning. They have some particular focuses for educational outcomes such as pupil achievement and time on-task. Teaching small groups was seen as a compromise between the ideal of individualised teaching and the practical difficulties this created for teachers.

Many scientists of pedagogic have researched the role of mutual interaction of people in the classroom and have valued it highly. Nowadays the Latvian researcher-pedagogue A.Spona and I.Maslo have developed interaction in educational activities in Latvia. They stress that the exchange of information, ideas and behaviour goes on to mutually interacting. The result of interaction is mutual influence and understanding. The total comprehension between teacher and pupil finds expression in community of opinions, motives and aims. It characterises the humanistic model of interaction.

The teacher uses different teaching methods that are suitable for each lesson. Therefore interactions of teacher and pupils in the classroom during one lesson can be with whole class, group of children and individual.

An essential task involved in effective teaching and interaction is the need for a teacher to establish and maintain authority over the class and management of pupils' learning. The teacher's authority needs to be based on effective teaching rather than on coercion. The teacher's authority is ensured by some factors. One of these – status and teaching competence of the teacher. Exercising control over the classroom and over discipline is very important. Enthusiasm and interest in the subject are a major contributor to establishing authority.

The interaction of teacher and pupil in classroom is very connected with educational outcomes and achievements. The positive outcomes associate with higher levels of interaction.

Methods. This research is carried out in Latvia Jelgava elementary school No4 during the 1998-2000 and included systematic classroom observation. Observations were conducted with 320 pupils of 5^{th} and 6^{th} grade age from 11 – 13. 130 teachers from elementary school took part in this investigation, too.

The interaction of teacher and pupil in the classroom is studied from view of teacher and view of pupil. As the previous observations and experience show these views are rather different. What form of interaction is used more by teacher? Why? What forms of interaction would teacher like to use? What forms of interaction would pupils like better? Why? What forms of interaction should be used by pupils to understand the lesson better? These are the main questions in the basis of this study.

The teachers have to make difficult decisions about how they can interact most effectively with all children. One of the backgrounds is the teacher and pupils personality and their individuality. The varieties of mutual interactions are managed in one lesson. Sometimes they often are used together in the same time. The teacher has to choose a form of interaction, which is the most necessary for this situation of classroom life and learning.

The pupil feels uncomfortable, when he doesn't like the interaction form between him and the teacher. Therefore pupil's personality is disharmonized. It makes farther acquiring of knowledge difficult. So it is necessary to find out a better interaction form to make learning process more effective.

Different research methods are used: discussion, questionnaires and observations in the current investigation. These are intermediate results of the larger research project.

A questionnaire was used to assess teacher and pupil thoughts about forms of mutual interaction. The pupil showed what forms of interaction make him understand the study material better. He could choose the answers: *the teacher directs his interaction to the whole class, *the teacher directs his interaction to a group of children, *the teacher directs his interaction to me individual, *and other ways. To measure interactions from the pupil's view, they were asked "How do you like three forms of interaction –whole class, the group of pupil, individual". They responded using a five point scale, ranging from like very much - like – don't mind – don't like - hate. The pupil marked what forms of interaction used are the most interesting within one lesson. The given answers were: * only work of whole class, *only work of group of children, * only individual work, * both work of whole class and of group of children, * both work of whole class and individual work, * both work of group of children and individual, * all three forms, * and other ways. The pupils explained their answers, too.

A questionnaire was also used to assess the teacher's position. The teachers were asked two series of questions, one oriented to the present, the other to the future, that is:

what forms of interaction do they use more? what forms of interaction would they like to use?

The teacher changes his choice of forms of interaction within one lesson very often. It depends on some factors, for example, the classroom climate, the pupil willingness to learn the theme from the curriculum, the background of the teacher, etc. For the question – "What determine the teacher's choice of form of interaction first?" – the teachers mentioned their option.

Mathematical and statistical methods were used for the analysis of the research results.

Results. Figures 1-6 illustrate the analysis of the questionnaire data. The result shows that pupil understands study better when the teacher directs his interaction to a group of children (46%), 31% of respondents understand the study material better when the teacher directs his interaction to the individual. Only 23% of respondents understand better when the teacher directs his interaction to the whole class (Figure 1).

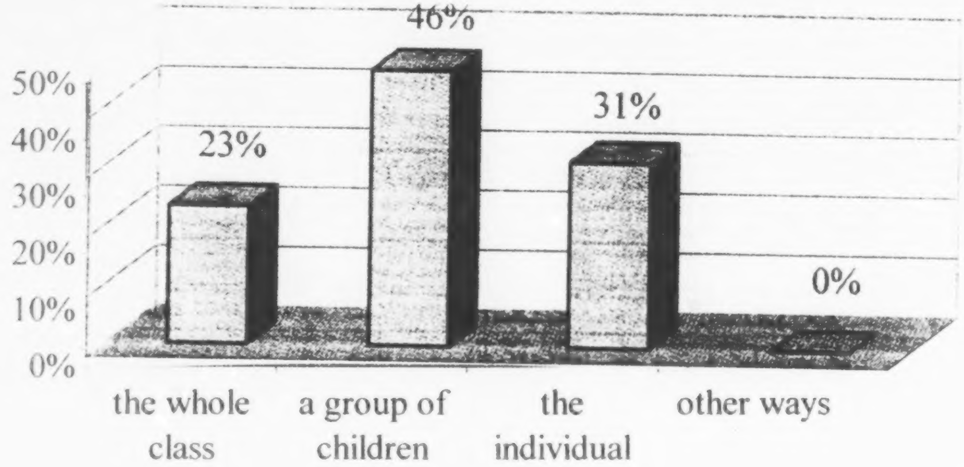


FIGURE 1. *The interaction forms to be used for the pupils to understand better.*

Figure 2 shows the result how the pupils like three previously mentioned interaction forms. Comparatively 35% of pupils like the group interaction very much, 12% of pupils - the individual interaction, but 9% of pupils - the whole interaction. The pupils responded with "like" the same as previously: 32% of pupils liked the group interaction, 28% of pupils liked the individual interaction, but 20% of pupils liked the whole class interaction. We can see dynamic changes of amplitude of percentage to indicators – "don't like" and "hate". Only 1% of pupils hate the group interaction, but 2% - the individual interaction.

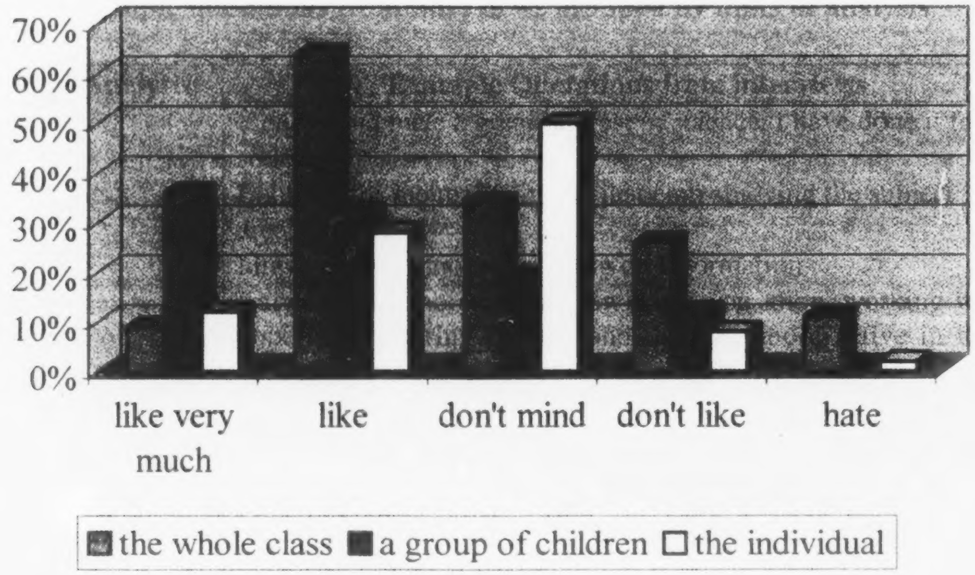
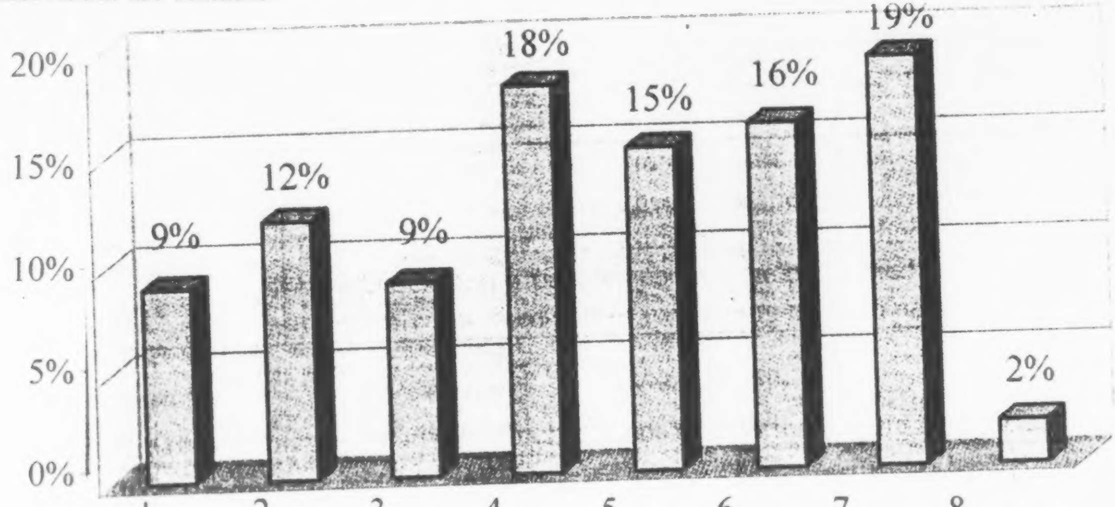


FIGURE 2. *The interaction forms liked by the pupils.*

The pupils very differently respond to forms of interaction used within one lesson (Figure 3), therefore the results are very similar. 19% of pupils showed all three forms: whole class, the group of children and individual. 18% of pupils – both work of whole class and of group of children. 16% of pupils – both work of group of children and individual. But just 9% of pupils thought that interaction only either with whole class or individual are suitable.



1 – only work of whole class work
2 – only work of group of children
3 – only individual work
5.- both work of whole class and individual
6 – both work of group of children and individual
7 – all three forms

4 – both work of whole class and of group of children	8 – other ways

FIGURE 3. *The lesson is more interesting for the pupils it these interactions are used.*

Integrating the parameters we acquired the data, that show that for 68% of pupils the most interesting are combined forms of interaction within one lesson, but for only 30% - one form of interaction (Figure 4).

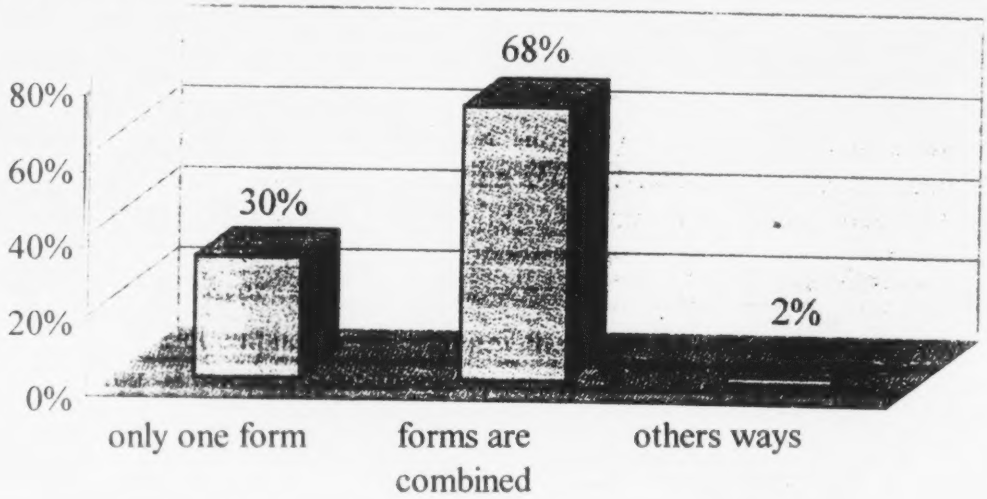


FIGURE 4. *The lesson is more interesting for the pupils.*

The teachers mostly use the interaction with whole class in their work (Figure 5). It is shown by the data of analysis – 52% of respondents indicated the interaction to the whole class, 33% - interaction to individual and 15% - interaction to a group of children.

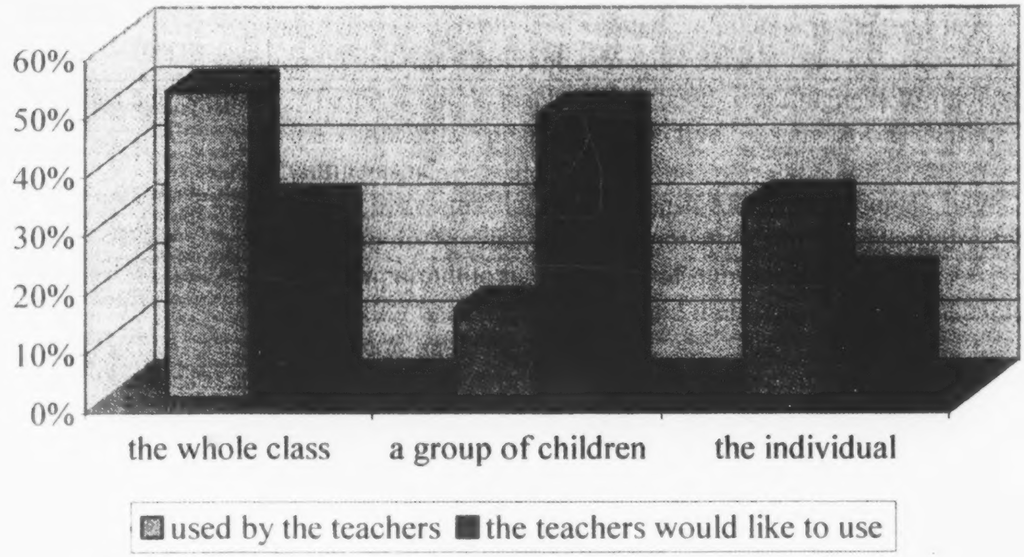


FIGURE 5. *The teachers' opinion about the forms of interaction.*

The teachers would like to manage different interactions that depend on teachers' individuality not on class. The results show (Figure 5) that teacher would like to use the interaction with group of children most (48% of respondents), with the whole class 32% of respondents and 20% of respondents with individual within one lesson.

The teachers indicated (Figure 6) that time (47%), the theme (25%) and class individuality (18%) determine the form of interaction. Only 10% of respondents showed different factors.

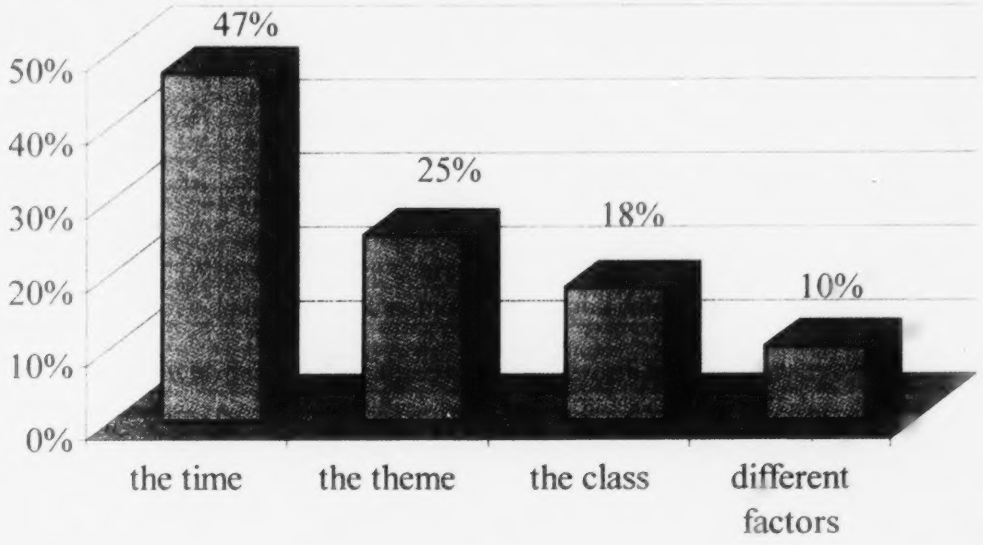


FIGURE 6. *The factors, that determine the choice made by the teachers.*

Conclusion. The teacher directs his interaction to the whole class, to a group of children and to individual. The pupils understand the study material better when the teacher directs his interaction to a group of children, but they have a problem when the teacher directs his interaction to the whole class. But the teacher directs his interaction to the whole class mostly. These results suggest a connection between interactions chosen by teachers and interactions wished by pupils. Teachers must make difficult decisions about the balance of the different forms of interaction they use.

The pupils like a group interaction very much, they don't mind individual work, but they hate whole class work.

The pupils like better when not only one form of interaction is used, but also they are integrated within one lesson. The most pupils showed a wish to combine all three interaction forms. The next best choice would be interaction of whole class and group work within one lesson. Just some pupils would choose interaction only with whole class or individual.

The teachers mostly direct his interaction to whole class at present, but they would like to use mostly the interaction with group of children in the future.

The time is one of the most important criteria to determine teachers' choice of forms of interaction. The high-ranking factors are also theme and class individuality.

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What's Inside Bodies? Learning about Skeletons and other Organ Systems of Vertebrate Animals

Sue Dale Tunnicliffe, Homerton College, Cambridge, UK
sue@sdtunnicliffe.demon.com.uk

Michael Reiss, Institute of Education, University of London, UK
m.reiss@ioe.ac.uk

The recent literature on the ways in which science curricula can prepare future citizens is extensive both with regard to science in general (Nuffield Foundation 1998; Reiss, 2000) and for biology in particular (e.g. Thomas, 2000). Our interest is based on the belief that a certain degree of knowledge about internal human anatomy is necessary for people to understand both how their own body works and, thus, some of the ways in which it can be kept healthy. Furthermore, such knowledge helps when communicating with doctors, nurses, midwives and other medical personnel. With the increasing debates about our use of animals and even whether non-human animals have rights, we further believe that citizens should have an understanding of the anatomy and physiology of other organisms, vertebrate and invertebrate.

Surprisingly few studies have looked at people's understanding of what is inside animals - skeletons and other organ systems. Perhaps surprisingly, given the central significance of the endoskeleton for the chordates and the inclusion of the skeleton in many science curricula, comparatively few studies have investigated pupils' knowledge about animal skeletons or the structure of animal organ systems (Driver *et al.*, 1994). Most in depth work has been done only on humans (Gellert, 1962; Williams, Wetton & Moon, 1989; Osborne, Wadsworth & Black, 1992; Cox, 1997; Teixeira, 1998), or on human skeletons only (Guichard 1995).

Much of the research about skeletons or organs has been in the form of interviews or has used drawings in some way. Drawings executed by primary children have been used to explore the understanding of biological concepts held by the pupils (e.g. Braund, 1996) but the creation of images and their relationship to the actual size of the specimen has not been explored. We decided to use drawings because the drawings of the pupil are their expressed model for their educational task which was to create a 2-D representation in the form of a drawing. The drawing is the representational model and is the outward expression of the mental model. In other words, what they draw is the expressed model for what they think is inside the animal.

We decided on a cross-sectional approach in which students of different ages would simply be presented with different animal specimens and asked to draw what they thought was inside the animals when they were alive.

Methods

This study looks at students' understandings of the structure of animal (including human) skeletons and the internal organs found in them. A cross-sectional approach was used involving a total of 175 students in England from six different age groups (ranging from 4 year-olds to 20 year-olds). A total of 572 drawings were made.

On separate occasions, the students were presented with a single dead specimen of a brown rat (*Rattus norvegicus*) (stuffed), a starling (*Sturnus vulgaris*) (stuffed) and a herring (*Clupea harengus*) (fresh). On each occasion the students were then asked to draw what they thought was inside the specimen when it was alive. On the final occasion, the students were asked to draw what they thought was inside themselves. After one or other of us had collected them, we jointly and repeatedly sorted through them, attempting to arrange them in a ranked order which we felt reflected different levels of biological understanding. Our ranking was informed both by previous work in the field (especially Osborne, Wadsworth & Black, 1992; Guichard, 1995; and Cox, 1997) and by our own knowledge of anatomy. No notice was taken of the student's ages in determining this ranking.

Results

The students made a total of 617 drawings. After we had collected all the drawings, we jointly and repeatedly sorted through them, attempting to arrange them in a ranked order which we felt reflected different levels of biological understanding. We were also extremely keen to provide a scoring system which gave as little credit as possible to the 'artistic' quality of the drawing and was as unambiguous as possible to score. Some of the older students professed an inability to draw well and we assured them that this did not matter. No notice was taken of the student's ages in determining the scoring system.

Eventually, we agreed on the following order for the biological quality of each drawing:

Level 1	No representation of internal structure
Level 2	One or more internal organs (e.g. bones and blood) placed at random
Level 3	One internal organ (e.g. brain or heart) in appropriate position
Level 4	Two or more internal organs (e.g. stomach and a bone 'unit' such as the ribs) in appropriate positions but no extensive relationships indicated between them
Level 5	One organ system indicated (e.g. gut connecting head to anus)
Level 6	Two or three major organ systems indicated out of skeletal, gaseous exchange, nervous, digestive, endocrine, urinogenital, muscular and circulatory

Level 7 Comprehensive representation with four or more organ systems indicated out of skeletal, gaseous exchange, nervous, digestive, endocrine, urinogenital, muscular and circulatory.

This scoring system requires a definition of organ systems. We used the following definitions for the eight organ systems:

Skeletal system	Skull, spine, ribs and limbs
Gaseous exchange system	Two lungs, two bronchi, windpipe which joins to mouth and/or nose
Nervous system	Brain, spinal cord, some peripheral nerve (e.g. optic nerve)
Digestive system	Through tube from mouth to anus and indication of convolutions and/or compartmentalisation
Endocrine system	Two endocrine organs (e.g. thyroid, adrenals, pituitary) other than pancreas [scored within digestive system] or gonads [scored within urinogenital system]
Urinogenital system	Two kidneys, two ureters, bladder and urethra *or* two ovaries, two fallopian tubes and uterus *or* two testes, two epididymes and penis
Muscular system	Two muscle groups (e.g. lower arm and thigh) with attached points of origin
Circulatory system	Heart, arteries and veins into and/or leaving heart and, at least to some extent, all round the body.

As is apparent, we therefore used the same, human definitions for organ systems when scoring each drawing, whether it was of a human, a rat, a starling or a herring. Our reasoning was that had we chosen to score each drawing on species-specific criteria (for example, air sacs in the starling), we would simply have shown that students know less about what is inside non-humans that they know about what is inside humans. Given the almost complete absence in current English biology curricula of any non-human anatomy, this finding is an obvious one. Instead, what we are looking at in part is the extent to which students presented their knowledge of internal human anatomy within their drawings of a rat, a starling or a herring. At the same time, we also made a complete list of every occasion on which a drawing showed some non-human internal feature.

The two of us then separately and independently scored all the drawings. Having agreed on the level (i.e. 1, 2, 3, 4, 5, 6 or 7), we then, for each of the eight organ systems, decided whether or not the drawing met the criterion for that organ system. If it did, we recorded the appropriate capital letter (S for skeletal, G for gaseous exchange, etc.). If it did not, we then decided whether or not at least one organ was present on the drawing for that organ system. If one was, we recorded the appropriate lower case letter (s for skeletal, g for gaseous exchange, etc.). Each drawing was therefore effectively scored a total of 17 times, once for the overall level, once for the presence or absence of each organ system and once for the presence or absence of at least one organ in each organ system. We agreed on in excess of 95% of scorings. In those cases where our views differed, we discussed each such case until we agreed.

As an illustration of how we analysed the drawings, Figure 1 shows the drawing done by a Year 9 girl (aged 14 years) of what she thought was inside herself. The drawing is scored 6GUsgndumc. In other words, the drawing shows two satisfactory organ systems - namely, the gaseous exchange and urinogenital systems - and seven of the eight possible organ systems - skeletal, gaseous exchange, nervous, digestive, urinogenital, muscular and circulatory - omitting only the endocrine system.

Data were entered into Minitab and Excel for analysis. All statistical tests are 2-tailed.

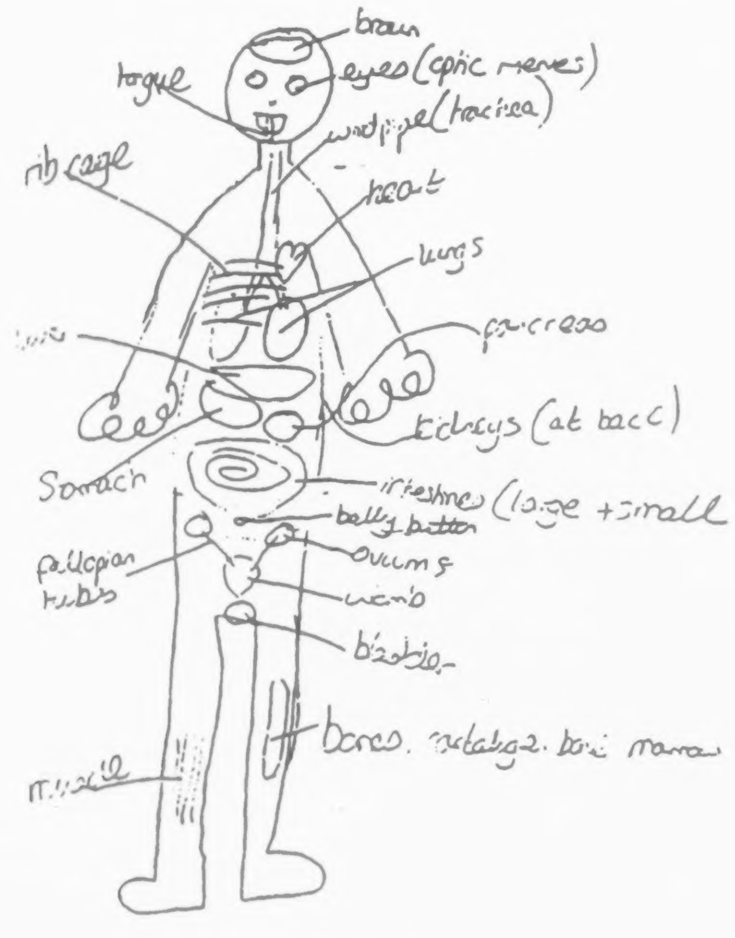
brain
tongue
eyes (optic nerves)
windpipe (trachea)
rib cage
heart
lungs
pancreas
liver
kidneys (at back)
Stomach
intestines (large + small
belly button
ovums ♀
fallopian tubes
womb
bladder
bones. cartilage. bone marrow
muscle

Figure 1

Students' Understandings of Organ Systems

Lumping together all the data, and thus ignoring differences between the drawings resulting from student age, gender, degree of biology specialism or the species being drawn, Figure 2 shows for each organ system the percentage of students whose drawing displayed an organ system as defined above in the Analysis section above. Two main findings are clear. First of all, for each of the eight organ systems, only a small minority of drawings show the organ system drawn sufficiently completely to be classified by us as an organ system. By way of illustration, in Figure 1 - one of the better drawings done by the 14 year-olds - just two of the eight organ systems are shown sufficiently to be classified as organ systems.

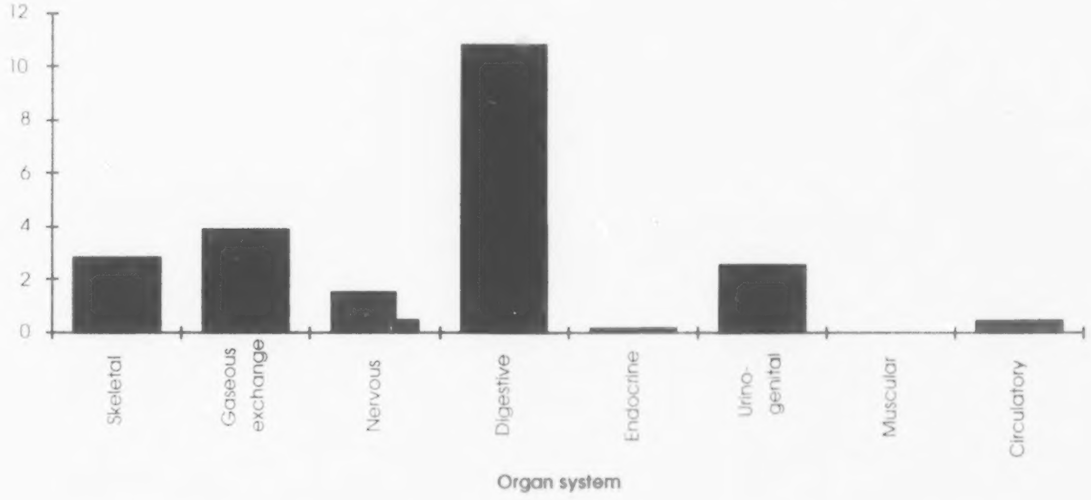

Figure 2 The percentage of pupils whose drawing displayed an organ system as defined in the paper.

Secondly, there are statistically significant differences between the eight organ systems in terms of how well they are represented ($c^2 = 192$; 7 df; $p << 0.001$). The best drawn organ systems is the digestive system represented in 11% of the drawings. At the other extreme, none of the drawings represented the muscular system, only 0.2% the endocrine system and only 0.5% the circulatory system as defined by us.

Students' Understandings of Organs

Again, lumping together all the data, and thus ignoring differences between the drawings resulting from student age, gender, degree of biology specialism or the species being drawn, Figure 3 shows for each organ system the percentage of students whose drawing represented an organ (rather than the entire organ system) as defined above in the Analysis section.

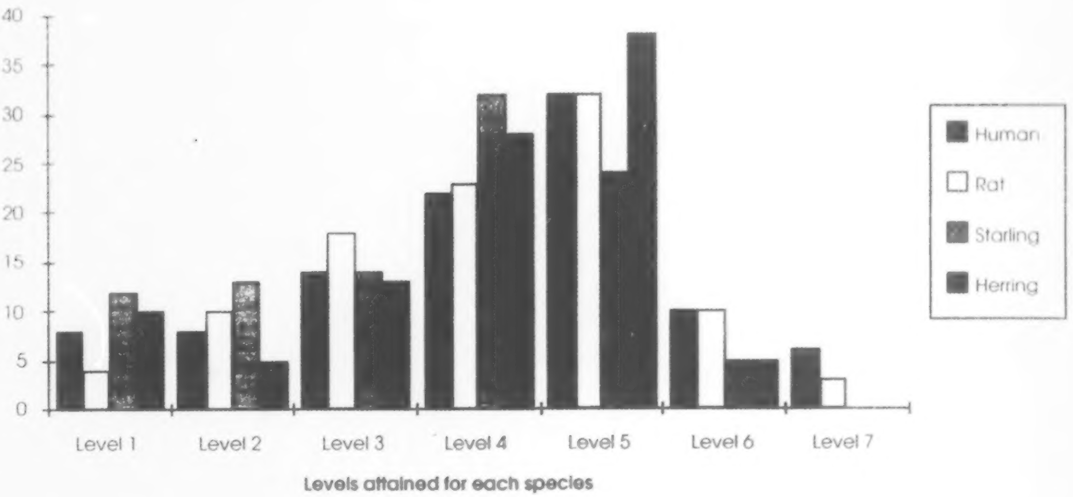

Figure 3 The percentage of pupils whose drawing defined an organ rather than the whole organ system for each type of specimen.

Not surprisingly, students do much better at this than at representing whole organ systems. For example, 51% of the drawings showed some portion of the skeletal system and 51% showed an organ (nearly always the heart) in the circulatory system. At the other extreme, only 0.5% of the drawings showed a part of the endocrine system. However, we do acknowledge that this last result is undoubtedly largely caused by our very narrow definition of what counted as being part of the endocrine system. In particular, we excluded the pancreas (which we classified as belonging to the digestive system) and the ovaries and testes (classified as belonging to the urinogenital system).

As was the case with whole organ systems, there are highly statistically significant differences between the likelihood of students drawing organs from the different organ systems ($c^2 = 505$; 7 df; $p << 0.001$). There are also certain clear differences between the rankings in Figures 2 and 3, notably with respect to the circulatory system which is poorly represented as a whole system (Figure 2), yet components of which are very frequently drawn (Figure 3). Indeed, there is no significant correlation between the rankings of how well represented whole organ systems and partial organ systems are ($r_s = 0.38$; $0.2 < p < 0.5$).

The Levels at which the Drawings are Drawn and Species-specific Differences

The data below show the percentage of drawings at each level, differentiated by the species being drawn:

Level	Human (n = 158)	Rat (n = 158)	Starling (n = 165)	Herring (n = 136)
1	1%	1%	4%	0%
2	9%	9%	12%	16%

3	5%	14%	10%	8%
4	50%	53%	51%	62%
5	16%	14%	18%	12%
6	13%	8%	5%	1%
7	6%	1%	0%	0%

Two main things are apparent from the above data. First, the modal level for each of the four species drawn is level 4. Secondly, any differences between species are probably small, with a suggestion that, as might be expected, the highest levels (levels 6 and 7) are more likely when pupils are drawings themselves. However, this conclusion is rendered problematic by the fact that different students were present on different occasions.

For this reason, Figure 4 shows the data just for the 78 students who were present on every occasion. (The proportion of drawings at levels 5, 6 and 7 is larger than in the overall sample as the biology undergraduates were particularly likely to be present on all four occasions and, obviously, produced many of the best drawings.) There is still a suggestion that drawings of humans (and perhaps rats) are more likely to be awarded levels 6 and 7 than the other taxa. If a c^2 test is applied to the raw data, the distribution of 6s and 7s across the four taxa (human = 16%; rat = 13%, starling = 5%; herring = 5%) is just significantly non-random ($c^2 = 7.84$; 3 df; $0.025 < p < 0.05$).

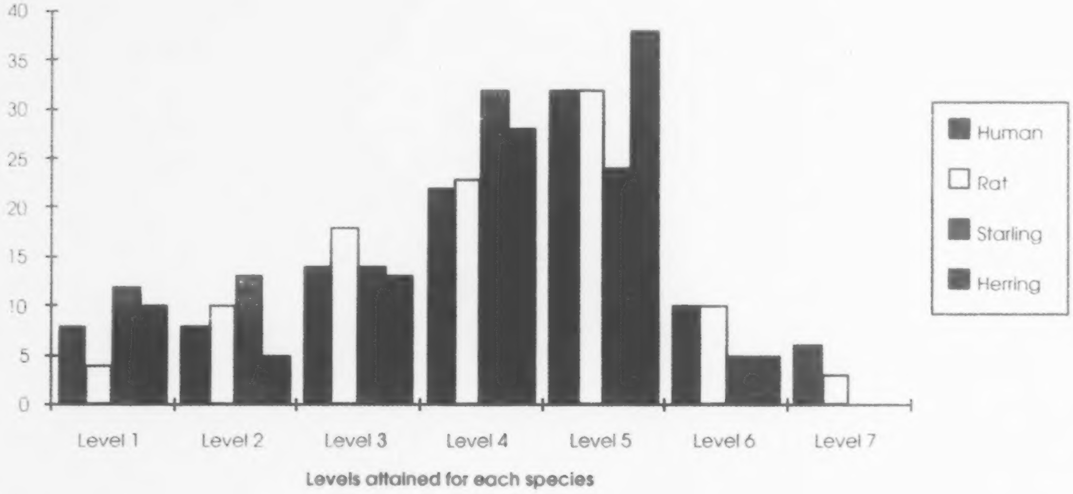

Figure 4 The data for the 78 pupils who were present on each occasion.

Closer examination of the drawings reveals much of interest with respect to what the students drew about the non-human animal. For instance, if we concentrate on just the drawings done by the Yr. 6 pupils - that is, 10 and 11 year-olds in their last year of primary schooling, Figure 5 shows a boy's drawing of the rat. The boy has successfully drawn bones in the rat's tail in addition to showing a range of organs found in the same places in humans and rats. Other Yr. 6 pupils had rat drawings with bones, nerves or muscles in the tail.

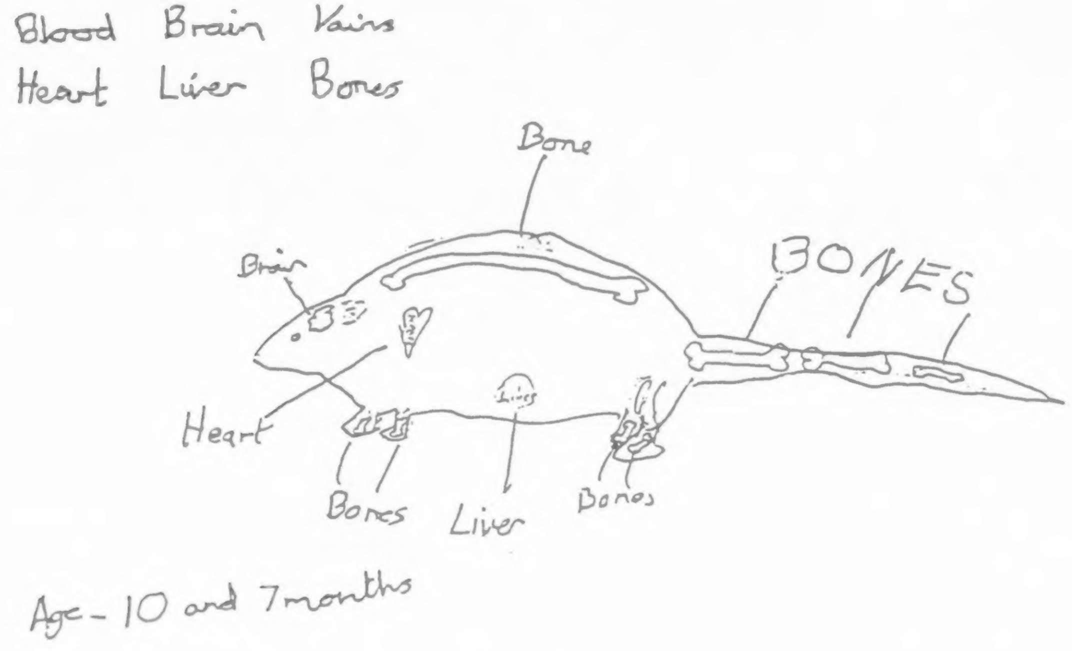

Figure 5

Figure 6 shows a drawing of the starling by a Yr. 6 girl. Noteworthy non-human features include the labelling of bones in the tail and the presence of giblets - presumably learned from domestic birds such as chicken. The genital area is labelled 'Rude bits'. (Elsewhere we have shown from an analysis of the drawings done by the Yr. 6 children of themselves, that 44% (eight in all) of the boys drew and/or labelled reproductive organs, in every case male reproductive organs. About the same proportion or possibly more, 64% (nine in all), of the Yr. 6 girls drew and/or labelled reproductive organs but strikingly most of these (seven out of nine) drew or labelled *male* reproductive organs (Reiss & Tunnicliffe, submitted).) Other Yr. 6 starling drawings portrayed tail feather muscles and showed a worm that had been eaten.

Finally, Figure 7 shows a Yr. 6 girl's drawing of the herring. Her drawing shows that she knows that there are muscles in the tail ('tail mucciel') and that the herring has 'Gills'. However, she also includes 'Lungs'. Many other Yr. 6 fish drawings showed gills. Three pupils drew and labelled 'egg dispenser' and two pupils clearly thought little of a fish's mental abilities. One boy drew and labelled 'small brain' and one girl wrote next to the brain the brain 'memory of two seconds'.

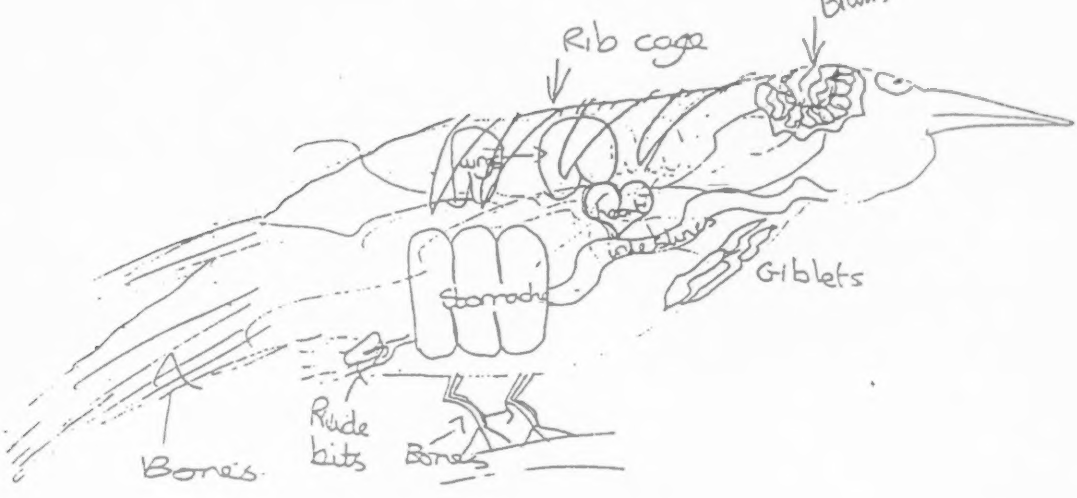
Brain
Rib cage
lungs
heart
intestines
Stomach
Giblets
Bones.
Rude bits
Bones

Figure 6

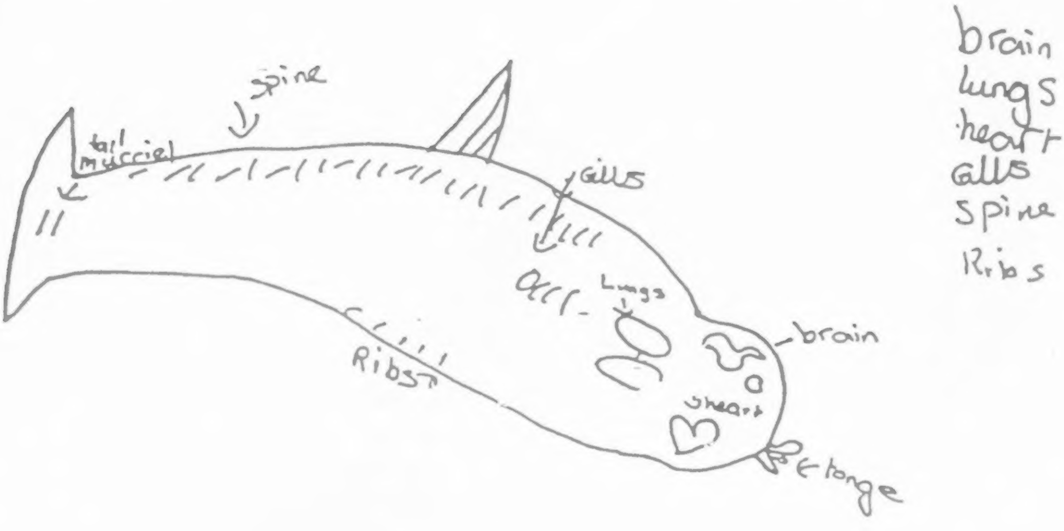
spine
tail musciel
gills
Lungs
brain
heart
tonge
Ribs
brain
lungs
heart
gills
spine
Ribs

Figure 7

The analysis suggests that, as would be expected, older students have a better knowledge of the animals' internal anatomies. However, even among the undergraduates (who were biology specialists) only a minority drew what we have decided is level 7. Gender differences do not appear important.

The students' knowledge of human internal structure is significantly better than their knowledge of rat, bird and fish internal structure. In England, where this study was carried out, such taxon-specific knowledge is probably largely a reflection of the anthropomorphic bias in today's curriculum: almost no non-human animal structure and function, sadly, is currently taught to 5 to 16 year-olds.

Discussion

We acknowledge that a more intensive methodology, for example one that combined drawings with subsequent interviews, would allow students more fully to demonstrate their understanding. For example, in some cases it was difficult for us to identify certain of the internal organs drawn. Interviewing would have allowed us to resolve at least some such uncertainties. At the same time, we were extremely keen not to cue students into those aspects of their drawings that were of particular interest to us. As drawings were done on a number of separate occasions, any interviews about the drawings would have had to have been undertaken after the last of the drawings had been obtained from each child. This would have been difficult given the number of students not present on every occasion.

We believe that the children learn about the organs as units and gradually piece them together so that eventually they form a mental model of a system, be it the skeleton , the digestive system or gaseous exchange. The fact that children aged five years who had just entered school had some understanding of what is inside animals reflects the public awareness and usage of terms related to the internal organisation of bodies, particularly blood, brains and bones and the heart. A particular concern of ours is the increasing loss of knowledge among UK pupils of organisms other than humans. In a related study (Tunnicliffe and Reiss, 1999b) we have shown that schools are significantly less likely to be cited by English pupils as sources of biological knowledge about the identity and taxonomic position of a range of animals than are other sources such as home, television and direct observation.

We found it noteworthy how few of the drawings reached level 6. And yet all that was required for level 6 was to produce a drawing with two of the major organ systems indicated (e.g. Figure 1). We strongly suspect that far too many students, however well they do on formal biology examinations, have only an atomistic knowledge of internal anatomy. Regrettably, English 'developments' in the biology curriculum and its assessment over the last ten years across the 5 to 16 age range have almost certainly reduced the chances of many students achieving a holistic understanding of much of what they study. Our belief is that too few of the students in this study, whatever their age, had any overall genuine understanding of internal anatomy, even their own.

Our work has clear implications both for ways in which schools might better encourage pupils to know about and understand the internal structures both of themselves and of other organisms, and for ways in which extra-school sources of scientific information, such as zoos, science centres and museums, might help. We are very interested to see whether studies in other countries would produce similar or different results and have initiated an international project collecting data about the knowledge of 7 and 15 years olds of the internal: arrangement of the human body.

Learning about animals and their internal organisation begins at home and reflects the public understanding of this area (Tunnicliffe & Reiss, 1999). We as biology educators need to find out what is this public understanding and to develop from that knowledge into biological knowledge as part of our pupils' education.

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Professional Development within Home Economics Teacher Training

Dislere, V., and Liepina, I.
Institution of Education and Home Economics, Latvia
dislere@cs.llu.lv

Introduction

While Latvian economy is stabilizing, social structure is changing and simultaneously welfare level is increasing, the intensified development of household as area of national economics. It can be connected to the managing of the cottage and individual farm in the frame of family farming, development of rural tourism, maintenance of specific Latvian landscape and ecological quality, as well as life – family life and management in Latvian farm under the conditions that corresponds to the nowadays understanding of socio-economic comfort. The described economic conditions will set up new tasks for education in school and qualification of teachers.

At present, schools in Latvia are under favourable conditions for developing alternative educational theories, teaching methodology and unconventional approaches. They facilitate work on cresting new teaching aids, developing up-to-date curricula, introducing more effective teaching and learning methods, as well as carrying out research programs.

The specialist of Home Economics is the professional of the highest qualification – teacher of Home Economics (HE) and Household for secondary level education with characteristics of academically educated personality, prepared to work in rural areas: schools, local authorities, agricultural advisory services as an advisor for household issues.

The criteria of teacher professional skills are :

1. communication;
2. using good methodology;
3. practical professional skills.

There are several highest educational establishment in Latvia who provide teacher training within Home Economics.

Accordingly the Household standard of General Secondary Education accepted by Ministry of Education and Science and keeping regulations of Standard of bachelor in Education, the teacher- training program within Home economics has made. The study scope are characterized by 200 Credit points (CP) for 5 year study programs and 160CP for 4 year study programs. One CP is 40 hours per week. From those 40 hours in schedule in different higher schools are planned different amount of lessons 16 – 24h. Another time students have to organize by himself in library, in workshops or their own work everywhere they like.

The speciality of Home Economics – Education at LUA is renewed since 1989, when the admission of new students was commenced at the Faculty of Food Technology, continuing the work of the Home Economics teacher training started by former Latvian Institute of Household (which was performing until 1944).

One of the most significant objectives for all the academic teaching staff dealing with training and Housekeeping and Trade is to develop and improve teaching and learning facilities. In Latvia the most topical problems in teaching and learning Housekeeping and Trade are as follows:

- the prestige of Housekeeping and Trade should be raised;
- schools lack highly qualified teachers. Every school needs staff with general, professional or academic educational background;
- to develop professional skill's within Home Economics training.

The main tasks for study program realization in Latvia university of agriculture Institution of Education and Home Economics are:

1. To develop and strengthen body of personality characteristics ensuring development of abilities and skills of self-education – a base for life-long learning process.
2. To ensure professional training of teachers according to the requirements of the existing Standard issued by Ministry of Education and Science for Household and Home Economics.
3. To prepare academically trained experts in field of Latvian ethnography and national craft, ready to maintain and develop the mentioned cultural-and-historical value.
4. To motivate for scientific interest in the problems of Home Economics and academic activities.

The core of the study program corresponds with Standard approved for the Bachelor's degree studies and in the frame of the mentioned Standard it is harmonized with study programs of certain European higher education establishments. The mentioned compliance allows student mobility between LLU and European countries, which is organized since 1999. LUA Home Economics study program has the following number of graduates:

1994/95	1995/96	1996/97	1997/98	1998/99	1999/2000
105	48	56	58	54	53

Teacher training programs in Latvia university of Agriculture is based on the awareness and hereditary of national traditions and educational directions in rural environment.

Nowadays, owing to the work carried out by the National Curriculum and Examination Center up-to-date methods of analysis and evaluation of students' achievements are being introduced.

Methods

In order to evaluate the achievements, development and perspectives of the speciality, to obtain and understanding of the speciality place among students, inquiries are carried out among students and teaching staff. The structured questionnaire (12 questions) was used to gather information in different areas of providing professional development for students. A group of 48 students and 17 from teacher staff of Home Economics speciality bachelor program (N=65) involved in the study. Duration of research – 2000/ 2001 study year.

Results and discussion

The ability of independent solving of work and social challenges, the personal readiness and competitiveness for the work at school are highly evaluated by the students. The study years have promoted interest in learning, acquiring new knowledge, although students would like to increase the proportion of special courses, as well as to widen the offer of elective courses.

The teaching staff proved that almost all lecturers continuously perfect the content of the study course and inform students about their requirements and evaluation criteria. 87 % of teaching staff considers that their main task is to encourage the interest of students on the course. The main source of inspiration(93 %) for study process improvement is studying of different methodical materials and publications (incl. foreign materials). 20 % of lecturers are completely satisfied with the results of their work, although the main factor, which hinders the teaching process, is lack of teaching aids (80 %).

The major part of the graduates are working in schools – 42%, higher education establishments – 5%, pre-school establishments – 26%; consequently 73% is working corresponding to the obtained profession. It gives evidence that the study program ensures the graduates competitiveness in the labour market.

Positive and negative in the study program

"+"	"-"
- high applied and artistic competence of the academic staff; - existing traditions of the Home Economics education; - succession (Latvian Institute of Household, Kaucminde, until 1994 which is continued today by education in the Dept. of Nutrition and Home Economics and Dept. of Pedagogy); - rich ethnography and Latvian national culture; - perspective – household is a stable branch of the national economy; - constructive-and-artistic approach; - orientation towards rural youth.	- inadequacy with the content of the European "Home Economics"; - scientific qualification of the academic staff; - high competition in the Latvian labour market; - insufficient financial provision of the study program.

The role of Housekeeping and Trade and its place among the other subjects depends on the objective and subjective factors, one of the most important subjective factors being the teaching - staff's attitude towards their work, their enthusiasm when preparing for their lessons, their ability to motivate school students for active involvement in the learning process. And it is obvious the both the teachers and the students obtain satisfaction when working creatively. The decisive role in motivating the school students belongs to the relatedness of their practical work to the needs of the real practical life. That is why at school it is necessary to relate the teaching and learning process with the economic activities of the country.

Conclusions

There are several suggestions for solving some of these problems:

- schooling should motivate school students to change their position, typical of socialism, when people were just pragmatic of the outcomes of their work. Nowadays a creative and rational approach is needed;
- teachers should motivate school students to acquire knowledge and skills. A posi-

tive attitude towards schooling is not formed automatically, but should be developed purposefully;

- when teaching Housekeeping and Trade emphasis should be put on improving practical skills, not neglecting also students skills to study theoretical literature and expertise of other specialists;
- New course programs should be designed. Some years ago the National Curriculum and Examination Center was established at the Ministry of Education and Research in Riga. It has elaborated the mine guidelines four course programs of all the subjects, taught at school. The guidelines indicate what knowledge and skills should be acquired by schools student. Nevertheless, teachers have free hands to choose teaching methods and techniques to be applied, as well as pertinent information, concepts, experience etc. This work should be done with a great sense of responsibility and creativeness;
- in the course of Ethnography students should be familiarized with the history of the country, its cultural values and historical traditions and customs. Meanwhile it is necessary to reconsider which traditions and symbols are significant for us at present and should be preserved and developed further;
- in the countryside secondary school students should be taught Housekeeping and Trade in accordance with the modern trends of regional economic development. The course programs should be related to rural entrepreneur ship that includes the arrangement of a country household, various handicraft activities, forest farming etc.
- The new contents of course programs require new criteria for students performance evaluation.

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Raising Motivation and Achievements in Learning Science Among Low Achievers Through Concrete Experiences and Multiple Intelligences Strategy

Oded Ben Menachem, Nir Orion, and Yaron Schur, Weizmann Institute, Rehovot, Israel
odedbm@kinneret.co.il.

Key words: low scholastic achievers; authentic learning; The outdoor as a learning environment; multiple intelligences; emotional intelligence

Introduction

Migration is a worldwide phenomenon (Cox, 1994). Migration waves create a culturally heterogeneous society, which is expressed in the emergence of culturally heterogeneous schools, and a disparity in terms of scholastic achievement between these schools and others.

During the past decade, Israel has absorbed two large waves of immigration, one from the former Soviet Union and the other from Ethiopia. Many of the last ethnic group students might be characterized as low scholastic achievers. These students tend to concentrate in specific schools and the intercultural encounter in such schools often leads to conflicts related to perceptions of abilities and different points of departure (Sever, 2000). Language difficulties and intercultural differences create a cognitive obstacle for such students while common science teaching methods are based on linguistic and mathematical-logical understanding.

The current article presents an intervention program aimed at cultivating a sense of success among students in classes with many low achievers new immigrants, and developing their cognitive skills. The program focuses on authentic learning that arises from the immediate outdoor environment. The basic assumption is that concentration on the natural environmental bears great potential for bridging between cultures. The concrete environment offers students an opportunity to deal with scientific issues through their senses, thereby creating emotional experiences and insights that are not culture-dependent. The sense of accomplishment that students derive from this experience is likely to serve as a springboard for increasing their scholastic motivation and improving their learning skills.

Aims of the Program

1. To assist low achievement new immigrant students to promote motivation to learn science.

2. To assist low achievement new immigrant students to develop an abstract and scientific thinking.

2. To help low achievers to learn sciences through diverse learning environments.
3. To by means of multiple intelligences.
4. To develop students' emotional understanding and desire to learn.

Principles of the program

The program is unique in its focus on activity in the environment, which makes it possible to demonstrate scientific principles to students in a way that relates to their intelligences, motivation, and interaction with peers and adults. It emphasizes the following three main principals:

1. The outdoor serves as a central learning environment, where the students learn through direct experience with concrete phenomena. The proposed sequence of learning develops from mediating interactions between the learners with their immediate and tangible environment – the landscape, the vegetation, and the wildlife. The relationship between the learner and the environment is built through dynamic observation of the outdoor environment and by use of visual and physical means for the purpose of constructing scientific principles.

2. The learning activities are modified according the seven intelligences defined by Gardner (1983, 1992). Students are given an opportunity to develop varied skills, which are the basis for understanding through multiple intelligences (Shimoni and Levin, 1998). The main activities are based on systems of symbols from kinesthetic, spatial, and musical intelligences. Symbols of mathematical-logical and linguistic intelligence enable interpretation of data in the class.

Thus the learning environment is composed of three spheres of reference, as illustrated described in figure 1.

Insert Fig. 1 about here

The first sphere of reference is the relationship to the immediate environment. This sphere includes experiential activity in the environment, which represents scientific knowledge. These activities begin with an authentic question that relates to the students themselves and enhances their awareness and insight regarding their environment. The activities are based on intake of stimuli through all senses and they mainly develop observation.

The second sphere of reference is that of the teaching approaches that promote response to the variance of students, such as the multiple intelligences approach, use of varied methods of assessment, mediated learning and development of motivation and emotional intelligence. This activity promotes the development of scientific concepts using constructivist approaches (Lutz, 1996).

Special emphasis is placed on the students' affective development (emotional intelligence). For this purpose, a special multiphase model was developed, based on development of awareness and work on emotional ties, empathy, and interpersonal communication (Goleman, 1995). All this is aimed at developing an "emotional person" with motivation to learn through involvement with the environment.

The third sphere of reference relates to development of a multidisciplinary sequence of teaching. This sequence constitutes authentic learning that develops thinking. This challenging, experiential, and interesting learning is founded mainly on building ties between science and technology and society (Yager, 1990).

The encounter between learning in the immediate environment and the special teaching approaches is meant to lead to the student's personal growth. The encounter between the special teaching approaches and the subject areas is meant to lead to development of self-direction towards learning. The encounter between learning in the immediate environment and the subject areas is meant to lead to the student's finding a meaning.

The meeting of these three spheres is meant to lead to creative thinking and productive knowledge.

Program Content

The program emerges from a sand dunes region that existed in a close environment of the school. In the last year, this area has suffered from massive mining and accelerated construction; as a result, this natural region is disappearing (Goren, 1999; Liberty, 1999). Thus it raises an environmental-social authentic question: Should we preserve the sand dunes or should we use them as a development area?

This authentic question is all the more salient in light of the students' observations of the theft of sand for the purpose of construction, which took place near their residences.

The content of the program is based on the Israel Ministry of Education's New Syllabus for Science and Technology (1996). The issues covered are part of a series of interdisciplinary subjects that includes elements of earth sciences, environment studies, technology, biology, astronomy, physics, and chemistry. The central axis is that of environmental issues, based on biotic and abiotic characteristics of the environment that are revealed in the course of dealing with an authentic question.

The subject matter is published in a series of special workbooks adapted for the target population and the special subject matter of the school. The plan is to publish a special set of workbooks for each region, addressing issues relevant to its immediate environment.

The following are the main subjects in the series used in this case:

1. **Introduction to the sand dunes**. The opening unit deals with initial observa-

tion of the sandy region. It includes classification of environmental elements, for the purpose of its characterization. The unit focuses on raising awareness about why it is worthwhile to study the environment. This awareness is important in capturing the students' attention for the purpose of learning.

2. **Materials.** This unit focuses on examining what sand is. It deals mainly with characterization and sorting rocks and minerals. Later in this unit, these sorting skills are used for the issue of characterization of life.
3. **Constructing buildings – Technology.** This unit concentrates on human utilization of materials from the earth, in general, and sand, in particular. The main focus is on the use of sand for construction. The unit combines observation with technology and research experiments.
4. **The cycle of materials on earth.** The unit deals with the rocks cycle on earth, focusing on the mineral quartz that constructs the sand grains and its history.
5. **Living on sand**. The unit deals with the adaptation of plant and animals to live in the sandy environment. It is based on observations and tracing footprints.
6. **The food web**. This unit deals with the reciprocal relations between living creatures and the sandy area, and among the living creatures themselves.
7. **'The sands are running out…"** This is an investigative unit, in which the students study issues related to living in the sandy region and the coexistence of the citizens of Israel and the sand, from all points of view.
8. **What you don't see from there, we see from here.** A conceptual journey that views preservation of scientific principles of earth on the moon.

Implementation of the Program

In order to implement this program, the following steps were taken:

Step 1: Building a Teaching Sequence

A teaching sequence was constructed on the basis of three components: The students; Fields of knowledge; the environment

The first component is the desire to help students fulfil their potential abilities and to reach a meaningful learning despite culture gaps. Therefore the choice of subject areas and skills includes value-related, emotional, and social considerations, in addition to those related to the discipline. The subjects are examined according to contribution of the scientific knowledge to the individual's development and thinking, as well as social integration. Special emphasis is placed on developing emotional intelligence, especially awareness and a sense of capability. The subject matter and methods of teaching are adapted to the students' cognitive and affective development and their intuitive knowledge in specific areas.

The second component is the study material (fields of knowledge), composed of knowledge in the natural sciences combined with an authentic multidisciplinary issue related to the immediate environment.

The third component is the immediate environment, included the substantive and personal meanings it holds.

Step 2: Supervisor Training

The development staff trained a group of 6 supervisors in program supervision and implementation skills for an entire year.

Step 3: Choice of the Schools

Two urban schools with a large population of Ethiopian immigrants were chosen. In both schools at least 20% of the student body is from this ethnic group.

Step 4: Teacher Training

The teachers were trained for a year in the subject matter and the special teaching approaches. The training focussed mainly on changing the teachers' attitudes towards students and the meaning of science education. Special emphasis was placed on teaching outside of the classroom.

Step 5: Supervised implementation of the program

During the implementation of the program, the supervisory staff met with the teachers on a weekly basis and also helped lead some of the activities.

Step 6: Constructive Assessment of the Program

The implementation activities were documented and assessed during the process of implementation.

Research Methodology and Process

The research is being conducted in two urban schools located in two different cities in the central of Israel. It began in July 2000 and is still in progress. The research methods are based upon qualitative methodology (Sabar Ben Yehoshua, 1995).

The central research question is: *Does the program generate significant change in the scholastic achievements and attitude towards learning sciences?*

This general question was translated to a series of practical questions:

1. *Has there been an improvement in the scientific knowledge and understanding among the students participating in the program?*
2. *Do the achievements of the students in the program differ from those of students in the regular program?*
3. *Has the attitude of the students towards the subject of science and technology changed as a result of participating in the program?*
4. *To what extent does the program change the students' emotional attitude to studies?*
5. *Are the students satisfied with the studies in the program?*
6. *What subjects did the students particularly like?*

The research instruments are based on data collection methods that were taught in the course of the implementation (in the cognitive-perceptual realm, the pedagogical realm and the emotional realm). The instruments include interviews of teachers, observations in the classrooms, documentation in assessment reports, and interviews with the students. Seven technology and science teachers, two instructors, and twenty students participated in the research.

Findings

The findings are preliminary and indicate only partial results of the initial process. It seems that the program leads to improvement in achievements. Examination of the results shows relatively high achievements of the underachieving population, compared to previous years.

Teachers commend the response of the students to learning, their motivation, the level of their answers, and the way that they perform assignments. According to the teachers, the students take interest in the subject and transfer the learning to life. A considerable portion of them brings newspaper clippings, ask questions, and demonstrate concern.

The teachers also note that the program leads to delegation of the responsibility for learning to the students and cultivates leadership. These traits were not found in previous programs.

The students also note their achievements in science studies. They claim that their interest in the material creates responsiveness to learning. Others note the clarity of the material and their ability to understand it.

The students say that the science teachers help them more, listen more, and relate to them more comfortably than other teachers in the school do. A considerable portion notes the high level of demonstrations and clarifications, as well as reinforcement of their understanding, which they gain through preparing the experiments. According to them, the sense of success and interest in the subject led them to change their opinion of this subject and they study it with greater interest.

Examples from the students' comments:

"The science lessons are different to other lessons. We take field trips and do experiments, so that the existential needs are clearer to us."

"The subject of science is unlike any other subject. We learn outside of the classrooms and understand ourselves and the environment more."

"Science studies help me understand myself and my family better."

"In science, I like to study. I understand two-thirds of the material, but friends and the teachers help me understand it all and succeed."

"Science is a great subject. We resolve questions and do experiments. If we don't understand, we get help and we always return with the answer."

The students note the importance of the emotional attention in the program. They claim that the program constituted a turning point in their attitude to studies and understanding themselves and their families, and this is very important to them.

The students' favourite subjects were: introduction to the sand dunes, followed by identification of rocks and technology. They got the most enjoyment from the field trips, following by the experiments in which they observed the rock and the use of the microscope to observe cells.

The students' and teachers' satisfaction with the program was very high and they are looking forward to continuing

Conclusions

The program is still in the implementation phase. On the basis of initial evaluation, it seems that it has led to some change in student attitudes and narrowing of culture gaps. It seems that the environment has the potential to promote learning of scientific concepts and to enhance the response of students with special needs to learning. Addressing multiple intelligences led to greater integration of the student populations and increased motivation.

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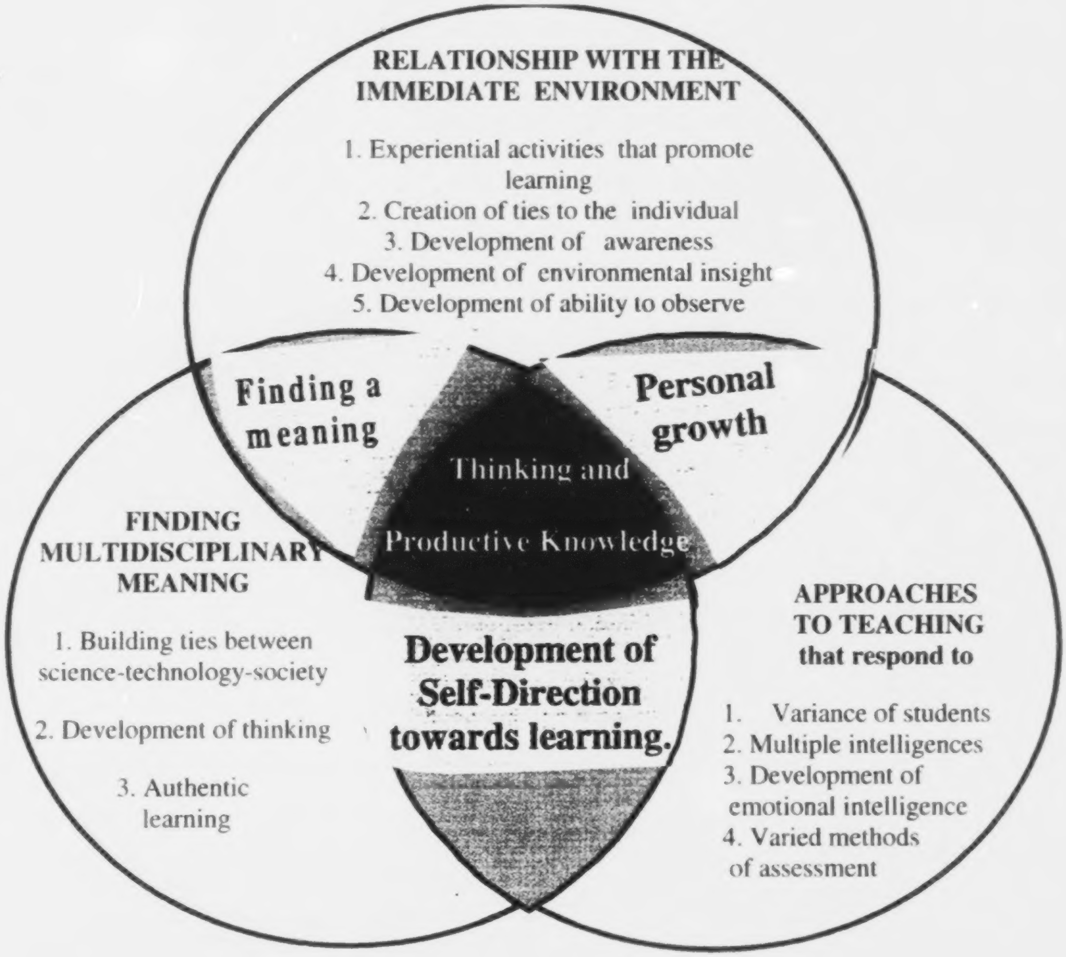
RELATIONSHIP WITH THE IMMEDIATE ENVIRONMENT
1. Experiential activities that promote learning
2. Creation of ties to the individual
3. Development of awareness
4. Development of environmental insight
5. Development of ability to observe
Finding a meaning
Personal growth
Thinking and Productive Knowledge
FINDING MULTIDISCIPLINARY MEANING
1. Building ties between science-technology-society
2. Development of thinking
3. Authentic learning
Development of Self-Direction towards learning.
APPROACHES TO TEACHING that respond to
1. Variance of students
2. Multiple intelligences
3. Development of emotional intelligence
4. Varied methods of assessment

Figure 1: The conceptual framework of the intervention program

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(Non)Objectivity of Results Obtained by Written Check of Knowledge

Biljana Steljic, Ljuba Mandic, and Jasminka Korolija
University of Belgrade, Yugoslavia
bsteljic@ helix.chem.bg.ac.yu

ABSTRACT

Knowledge check is a constituent part of the teaching process. The results for acquired knowledge level are equally important to both pupils and teachers. The results achieved should be guidelines for changing and upgrading of curricula as well as for a manner of their performance. Therefore, it is necessary to check knowledge as objectively as possible.

In the field of education there are no fully accurate means whereby level of knowledge can be measured. This is the reason why only tendency to objectivity can be present in education. The objectivity of test results certainly depends on the relevance of a task/type of a task, definition of what the task is to check, and the manner of task recognition and evaluation. To determine the degree to which the said factors contribute to (non)objectivity of the results, a test was constructed whereby the knowledge of basic concepts of oxidation-reduction was to be checked: oxidation number, oxidation-reduction equation, oxidation-reduction agents, and electrode potential. The test comprised 17 tasks of various types. Testing was carried out using a sample of 170 high-school students.

The analysis of the results obtained for checking the level of acquisition of a single concept (oxidation-reduction agent) was done through a number of tasks/types of tasks (alternative choice, alternative choice with a supplement, multiple choice). It was found that conclusions on the degree to which some concept had been acquired, based on the results for single tasks, often leads to incorrectness-nonobjectivity. Accordingly, to gain as objective insight into knowledge level as possible, the test should check as small number of concepts as possible, and the knowledge of a single concept should be checked by as much different types of tasks as possible. Thus, correction of single results as well as more objective knowledge check is made possible.

Key words: knowledge testing, objectivity, number of concepts, types of tasks

INTRODUCTION

Knowledge check is a constituent part of the teaching process. The results for acquired knowledge level are equally important to both pupils and teachers. The results achieved should be guidelines for changing and upgrading of curricula as well as for a manner of their performance. Therefore, it is necessary and important to check knowledge as objectively as possible.

In the field of education there are no fully accurate means whereby level of knowledge can be measured. This is the reason why only tendency to objectivity can be present in education. Standardization of tests is one of the ways for increasing test objectivity (1). Despite the fact that standardized tests have adequate measuring characteristics, it can not be always claimed that percent of correct answers obtained by doing them is a measure of the level of some concept acquisition. Test standardization procedure is mainly undertaken in large-scale research projects but not when tests are constructed for use in everyday school practice. In addition, tests whereby objective results have been obtained can not be employed indefinitely. If knowledge is steadily checked by means of the same test, it may result in a pattern that the teacher will always employ in presenting teaching contents. That is why, in their everyday teaching practice, teachers by themselves construct tests for knowledge check, using their own knowledge and experience.

Numerous investigations, presented in literature, dealing with curricula and modes of their presentation, ended up with written check of knowledge. Conclusions were drawn, generalizations were produced based on the results for concept acquisition. When tests, tasks, type of tasks and results are analyzed, sometimes it can be found that tasks are not suited to making generalizations based on the results obtained. Wrong conclusions about the level of acquired knowledge may result from a number of causes. Some of them are:

- irrelevance of a task/type of a task
- it has not been defined what the task should check
- inappropriate recognition of correct answers, task evaluation (2).

To check the extent to which the said factors contribute to (non)objectivity, a test of knowledge check on fundamental oxidation-reduction concepts was constructed: oxidation number, oxidation-reduction equation, oxidation-reduction agents, and electrode potential. Testing was done on a sample of 170 high-school pupils.

Results and Discussion

The test consisted of 17 tasks of various types (alternative choice, alternative choice with a supplement, multiple choice, pairing, ranking, "arcane" substance, stating). We hereby present only a number of tasks, considering them to be a good illustration of mistakes that may be the outcome of wrong interpretation of the results.

The knowledge of oxidation properties of permanganate anion was checked by means of an alternative choice task (Task I):

Permanganate anion is not a reduction agent. YES NO

Correct response was provided by 47.9% of pupils (Fig. 1, Task I).

In the multiple-choice task, out of five offered (MnO_4^-, NO_3^-, S^{2-}, K^+, O_2^{2-}), pupils were to choose ions that are reduction agents. 33.7% students chose permanganate anion (Fig. 1, Task II). We could conclude that the rest of 66.3% of pupils know that permanganate anion is an oxidation agent.

The conclusion that a large number (47.9% and 66.3%) of pupils know that permanganate anion is an oxidation agent, based on either results, would be wrong. Namely, by analyzing pupils' responses in both tasks, it was found that:

- 16.6% of pupils who responded correctly in Task I that permanganate anion is not a reduction agent choose it as a reduction agent in Task II,
- 35% of pupils who think that permanganate anion is a reduction agent, based on the results for Task I, do not choose it in Task II,
- 17.1% of pupils respond incorrectly in both tasks.

The analysis demonstrates that only those pupils who provided correct responses in both tasks (31.3%) know well the characteristics of permanganate anion (Fig.1, corrected results - C.R.).

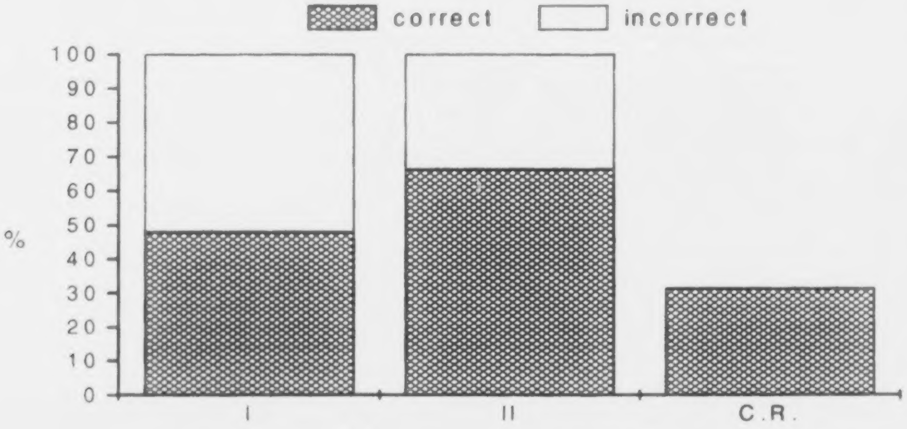

Fig. 1. Level of acquisition of the oxidation-reduction agent concept (MnO_4^-)

To do those previous two tasks, a pupil had to associate the following concepts: oxidation and reduction agents (definition), a formula MnO_4^-, oxidation number. To check a broader knowledge about the exchange of electrons between oxidation and reduction agents and probably to encourage pupils to correct their previous responses, two tasks were posed. The statement given in the task of alternative choice (Task III) was contrary to that given in the task of alternative choice with a supplement (Task IV), where an explanation was to be provided for a given response by choosing one out of five offered responses (2).

Task III

In reactions an oxidation agent gives off electrons, while a reduction agent receives them. YES NO

Task IV

In reactions a reduction agent gives off electrons. YES NO

This means that:

a) oxidation number is being reduced in a reduction agent
b) reduction capacity is being increased in a reduction agent
c) the number of electrons is being reduced in an oxidation agent
d) charge is being reduced in an oxidation agent
e) electrode potential is being reduced in a reduction agent

In Task III a correct response was provided by 59.4% of pupils, while in Task IV 75.6% of pupils provided a correct response (Fig. 2). In both tasks 52.4% pupils responded correctly (C.R.), 24.1% responded correctly and incorrectly, 16.5% responded incorrectly to both questions, and 7% did not respond to all questions. Both correct responses and correct explanation (charge is being reduced in an oxidation agent) was provided by 10.6% of pupils (Fig. 2, EXPL.).

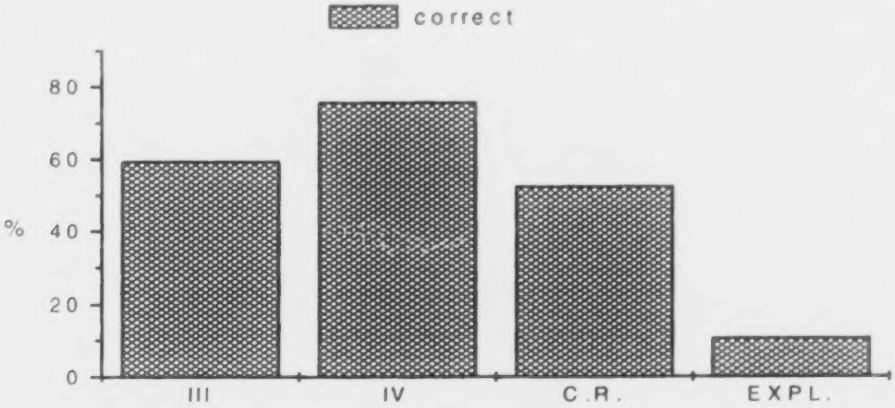

Fig. 2 Level of acquisition of the oxidation-reduction agent concept (definition)

From the results presented for all four tasks, it can be concluded more confidently that 52.4% of pupils know the definition of oxidation and reduction agent, that 31.3% can apply definitions to a concrete case, and that 10.6% are able to provide an explanation too.

In addition to these examples of tasks a few more were analyzed, whereby knowledge about the concepts of oxidation-reduction was analyzed.

Knowledge about the relationship between the value of redox potential in some elements and their mutual behavior was checked by means of various types of tasks: alternative choice, multiple-choice and ranking.

In both ranking tasks (Tab. 1) the same elements were to be placed in a corresponding row. Correct responses show that 20% of tested students know about the relationships between reduction properties of the said elements i.e. that values of potential are the result of their oxidation and reduction properties. Since the results achieved for task V and VI were nearly identical, it was assumed that the same students responded correctly to those two tasks. However, the analysis of individual responses evidenced that only 4.7% of students provided correct responses for both tasks. Additional analysis showed that we could have reached wrong conclusion that knowledge about redox potential of given elements had been acquired, judging by one of the tasks only.

Tab. 1. Perecent of correct responses for tasks of ranking

V Arrange the following elements according to the growing redox potential. 1.$E_{Fe^{2+}/Fe}$ 2. $E_{H^{+}/1/2H_2}$ 3.$E_{Ag^{+}/Ag}$ 4. $E_{Cu^{2+}/Cu}$ 5.$E_{Zn^{2+}/Zn}$	20.0%
VI Arrange the following elements according to the growth of reduction ability. 1. Hydrogen 2. Copper 3. Zinc 4. Silver 5. Iron	21.2%
Right V and VI	4.7%
Right V/Wrong VI	14.7%
Wrong V/ Right VI	14.7%
Right V and VI	45.9%
Other combinations of responses	20%

In the said tasks, apart from the relationships between redox potential of other metals, knowledge about the relationship between copper and iron is tested. It was assumed that students who had arranged metals correctly in task V would provide correct responses for these two metals too. This question was posed through alternative-choice task (task VII). Percent of correct responses and analysis results in the same students for tasks VII and V are given in Tab. 2.

Tab. 2.Percent of correct responses in tasks of alternative choice and ranking

VII Copper has lower redox potential than silver. YES NO	45.3%
Right VII and V	10.6%
Wrong VII/ Right V	8.2%
Right VII/Wrong V	28.8%
Wrong VII and V	28.8%
Other combinations of responses	23.6%

In two multiple-choice tasks students were to choose pairs between which reaction can take place. The tasks are shown in Tab. 3. In these tasks, responses accepted as correct were only those if wrong responses were not chosen along with them. Percent of correct responses in the said tasks was very low. The analysis of each single response showed that a portion of students (4.2%) who choose a pair Cu^{2+} + Zn as correct in one task choose an incorrect one Cu + Zn^{2+} in another. Thus, previously given percent in task VII should be corrected by subtracting the percent of students who choose incorrect response in tasks IX, which annuls previously correct response.

Tab. 3 Percent of correct responses for multiple-choice tasks

VIII Of the pairs given, the following will react: a) $Na^+ + H_2$ b) $Zn^{2+} + H_2$ c) $Fe + Zn^{2+}$ d) $Cu^{2+} + Zn$ e) $Cu + H^+$	8.9%
Corrected result for the choice of incorrect response in task IX.	4.7%
IX Reaction will take place in the case (cases) of: a) $Zn + Na^+$ b) $Cu + Zn^{2+}$ c) $Mg + Fe^{2+}$ d) $Fe + Na^+$ e) $Na^+ + Cu$	11.1%

In all given examples, it was proved that more objective conclusions on the level of knowledge acquired about some concept can be drawn only on the basis of analysis and correction of results obtained by a number of tasks for the same concept.

Conclusion

The present paper examined the degree to which the objectivity of test results depends on the relevance of a task/type of a task, determination of what the task is to check as well as on the manner of task recognition and evaluation. Therefore, the results were analyzed, obtained by checking the level of acquisition of a single concept through a number of tasks/types of tasks. The analysis showed that conclusions on the level of acquisition of some concept, based on single results of tasks, can be incorrect. To obtain as objective insight into knowledge level as possible, the number of test-checked concepts should be as low as possible, whilst the knowledge about a single concept should be checked by as many different types of tasks as possible. This method of knowledge check allows for correction of single results and more objective knowledge check.

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Children's Understanding of Dissolving: The Influence of Visibility of the Process. Implications for Teaching

Eve Kikas, University of Tartu, Estonia
eve@psych.ut.ee

In daily life, children see various processes of dissolving: sugar in the water seems disappearing while cocoa powder's dissolving seems like distributing in the water. However, both processes are called dissolving. Children develop the concepts of materials and their changes, basing on what they see and hear in daily life. Vygotsky (1934/1997) argued that the first – everyday – concepts develop from concrete perceptible instances, they are vague and depend on their referents and contexts. According to Vygotsky, children may explain the dissolving of different substances differently; it means that children's concepts of dissolving may be context-specific and dependent on the features of the solute. Other researchers stress that children's everyday concepts are incorporated into naive domain-specific theories (Au, 1994; Carey, 1991). Au (1994) argues that children possess a theory which says that matter has homogeneous structure. According to this view, substances can be broken into smaller and smaller pieces but still preserve their properties. This holds true even if the pieces of substance become so small that they are invisible. According to this view, children's understanding of dissolving is not influenced by the visibility of the process.

Later, in school, children are taught about dissolving and other physical and chemical processes. As the microscopic processes are not directly observable, the exact usage of language to describe and explain the phenomena is very important. Vygotsky (1997) referred to the concepts learnt in school through verbal definitions and explanations as scientific. However, if pupils learn new verbal explanations but do not understand them, different misconceptions that are based on their previous concepts and knowledge acquired from teaching, evolve. It has been shown that misconceptions often describe the behaviour of particles in terms of perceptual macroscopic entities (Albanese & Vincentini, 1997; Griffiths, 1994; Krnel, Watson, & Gla_ar, 1998). It means, students' concepts are still dependent on the visible side of the process. In addition, misconceptions arise due to confusing specific scientific terms with everyday language (Driver, 1985; Garnett, Garnett, & Hackling, 1995). It means that the sources of misunderstanding are the same both before school and in school.

The concept of dissolving has been studied a lot, but quite ambiguous results have been reported. Piaget and Inhelder (1941/1974) found three stages of the concept of dissolving. The youngest children thought of dissolving as of disappearance of the solute, elementary-grade pupils as of liquefaction, older pupils as of breaking or pushing larger particles into pieces. Later studies have shown that even younger children appreciate that substance continues to exist after it has become invisible upon dissolution (Au, Sidle, & Rollins, 1993; Rosen & Rozin, 1993). Au et al. found that 75% of the 6-year olds and 90% of the 7-year old children of the sample stated explicitly that there was still sugar in dissolution. Rosen and Rozin (1993) found no differences between various white substances in accepting the conservation of taste during dissolving and referring to the particles.

But, on the other hand, even older (9-16 year old) students' understanding of dissolving is quite unclear. They explain dissolving as disappearing, breaking up, decomposing, distribution (Prieto, Blanco, & Rodriguez, 1989), mixing (in the sense of displacement), liquefaction (Krnel et al., 1998), turning into water or combining with water (Driver, 1985; Driver, Squirer, Rushworth, & Wood-Robinson, 1995). Students think of melting and dissolving as synonyms or mix the terms up (Driver, 1985; Driver et al., 1995; Krnel et al., 1998; Lee, Eichinger, Berkheimer, & Blakeslee, 1993; Prieto et al., 1989). Children think that sugar is not the same in the dissolution (Driver, 1985).

So far, a great majority of researchers have studied the understanding of the dissolving of sugar in the water (Au, 1994; Au et al., 1993; Driver, 1985; Johnson, 1998; Lee et al., 1993; Piaget & Inhelder, 1974; Rosen & Rozin, 1993). However, dissolving of sugar is specific in several senses: children have experience with it from very early on and during the process sugar seems to disappear. Rosen and Rozin (1993) who compared the acceptance of conservation of taste and flavor during dissolving of different invisible substances (sugar, citric acid, soap powder and polycose) have carried out an exceptional study. They found that the results did not depend on substance. However, all these substances were white and became invisible during dissolving.

There are several reasons to clarify children's conceptions of dissolving. The processes of dissolving of white and colored substances appear to be different. Therefore, it is a good case to study if everyday concepts are perceptually bound (Vygotsky, 1997) or used more coherently (Au, 1994; Au et al., 1993). If they tend to be more perceptually bound, different concepts of dissolving should develop about the visible and invisible processes. In addition, everyday language misuses the terms dissolving and melting (e.g. in Estonian, dissolving of sugar is frequently called melting), giving a possibility to study the influence of everyday language on the development of concepts. As students' preliminary concepts heavily influence how they interpret the new information taught in school, it is also important to know them to design new curricula (Glynn & Duit, 1995; Schnotz, Vosniadou, & Carretero, 1999).

The studies described in the paper are carried out as a part of the larger project on the development of children's concepts of matter and its changes. In this paper, the impact of visibility and familiarity of the process of dissolving on children's concepts is analyzed. Two different studies with kindergartners and third graders were carried out. We expected that 4-10-year old children do not have clear and compact understanding of dissolving of matter and its conservation. They give incompatible answers in different tasks. These are concepts that children have developed basing on what they see and hear in their daily life (i.e., everyday concepts) (Vygotsky, 1997). In addition, we hypothesized that children describe differently the dissolving of visible matter as compared to invisible one.

Method

Participants

The participants of the study included 66 kindergartners (21 four-year olds, 20 five-year olds and 25 six-year olds, approximately the same number of boys and girls) and 78 nine-ten-year old schoolchildren (approximately the same number of boys and girls). The participants had not received any formal teaching about the molecular structure of matter.

Procedure, tasks and coding

Children were interviewed individually. The interviewer and a child sat alone in a room. Interviews lasted for 15-30 minutes. Tasks were developed basing on the earlier research (Au et al., 1993; Driver et al., 1995). All the tasks were accompanied by demonstrations: children were shown the dissolving of different solid substances in water.

With kindergartners, four substances were used: potassium permanganate (colored and unfamiliar); cocoa (colored and familiar); sugar (white and familiar); and citric acid (white and unfamiliar). Before asking the questions, interviewer talked about the substance and its taste. Half of the children were first asked about colored substances, another half about white substances. Only two substances were used with schoolchildren: potassium permanganate (visible) and sugar (invisible and familiar) with group I and potassium permanganate and citric acid (invisible and unfamiliar) with group II.

The questions and the categorizing of answers are given in Table 1. Schoolchildren were not asked about the taste as even younger children gave mainly conservation-answers to this question.

Table 1. Questions and the categorization of the answers

Question	Non-conservation answers	Conservation answers
1. What happened with sugar (citric acid, potassium permanganate, cocoa)? /after it had been put into the water and stirred/	Disappearing, changing, I don't know	Distributing, dissolving, melting
2. Is sugar (citric acid, potassium permanganate, cocoa) still in the water? [1]	No	Yes
3. What happened to the water? /after the substance had been put into the water/	I don't know	Change in color, change in taste, mixing of substances
4. What is the taste of this? [1] [2]	The taste of the water, I don't know	The taste of the substance or correct evaluations

[1] Children had to explain their answer.

[2] These questions were not asked from schoolchildren.

Results

As no age differences occurred inside the younger group, the results will be analyzed together in this group. The results of the younger and older children will be compared.

Conservation of taste during dissolving

The far majority of children stated that the solution had the taste of the substance (82% for sugar and citric acid, 83% for potassium permanganate and 88% for cocoa). No significant differences in conservation-answers were found between substances and between children who first saw the dissolving of colored as compared with those who saw white substances. Children explained their answers in three ways: "I saw that you put the substance into the water", "I have tasted it" and "mother/father has taught it". Significantly less children explained their answers to potassium permanganate, as compared with cocoa ($Q=11,63$, $p<.001$) and sugar ($Q=5,54$, $p=.018$). Of those 43 children who gave conservation-answers to all the substances, less explanations were given to unknown substances: potassium permanganate as compared with sugar ($Q=12,00$, $p<.001$) and cocoa ($Q=7,14$, $p=.002$); citric acid as compared with sugar ($Q=5.44$, $p=.02$) but not with cocoa.

Dissolving of different substances in the water and their conservation

Kindergartners

Figure 1 provides the distribution of answers (in percentage) to the question "What happened with the substance?" for all the four substances. It is seen that few children used the terms "melting" and "dissolving" for white substances. The majority of children talked about dissolving of colored substances as of distribution but of white substances as of disappearing or changing (i.e. gave non-conservation answers). From these answers, we can infer that children may think that colored substances conserve in the water while white substances don't. The difference in conservation-answers was significant between colored and white substances (between citric acid and potassium permanganate: $Q=12.6$, $p<0=.001$; citric acid and cocoa: $Q=12.46$, $p<.001$; sugar and potassium permanganate: $Q= 6.82$, $p=.009$; sugar and cocoa: $Q=6.55$, $p=.01$).

However, the majority of children answered to the explicit question "Is the substance still in the water?" affirmatively. There were no significant differences between the substances (64% for sugar, 74% for citric acid, 73% for potassium permanganate and 71% for cocoa). The difference between conservation-answers for different questions was significant only for citric acid ($Q=19.6$, $p<.001$). In their explanations of conservation, children told that they had seen that the substance had been put into the water. In explaining non-conservation, children stated that the substance had changed.

The descriptions of the change of the water also depended on the visibility of the substance: children referred mainly to the change in color if the colored substance was put into the water but to the taste if the white substance was put into the water (see Figure 2). Children gave also more "I don't know"-answers for white substances as

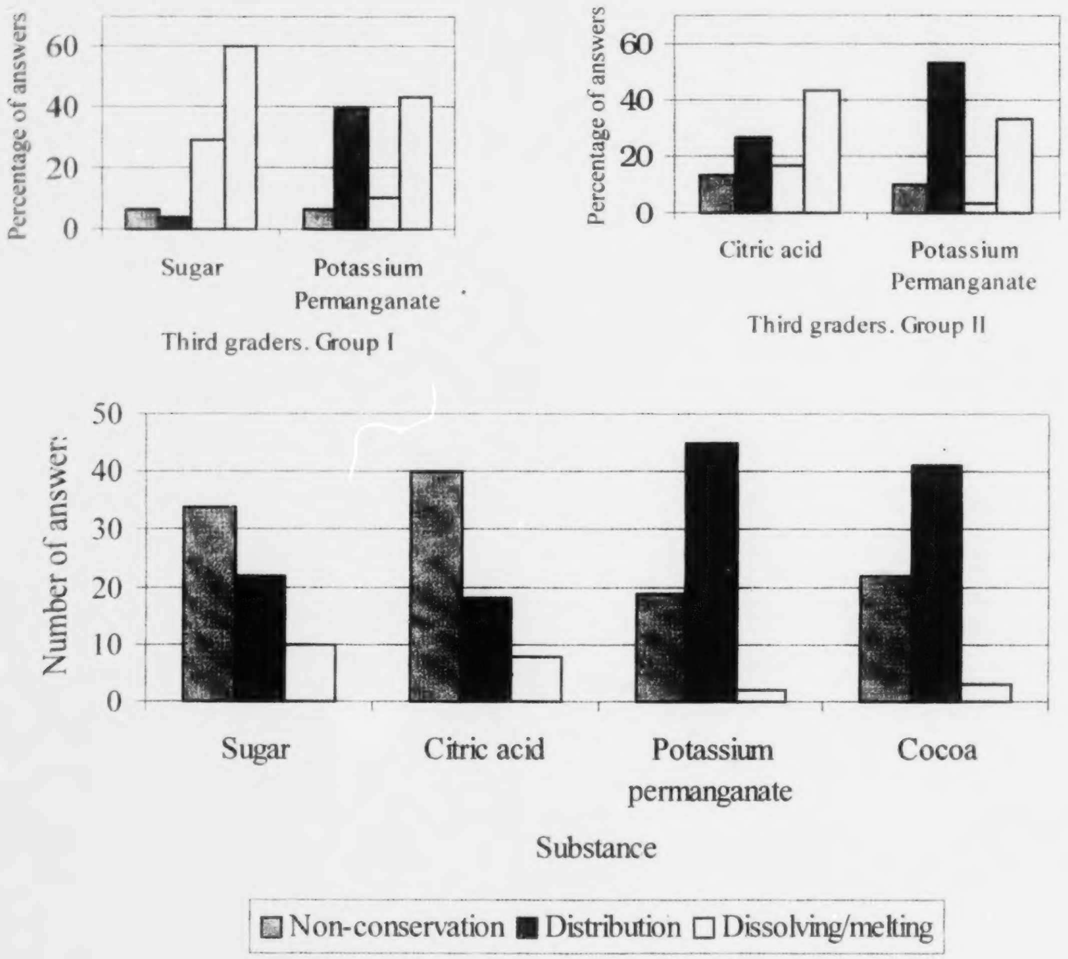

Figure 1. Distribution of answers to the question "What happened with the substance?" /after it had been put into the water/

compared with colored ones, the difference was significant between potassium permanganate and citric acid (Q=4.76, p<.03) and potassium permanganate and sugar (Q=5.00, p<.03). Those children who first saw the dissolving of colored substances referred more to the change in color for the dissolution of white substances (for citric acid (¯Ç(2)=10.35, p=.006, for sugar ¯Ç(2)=5.99, p=.049).

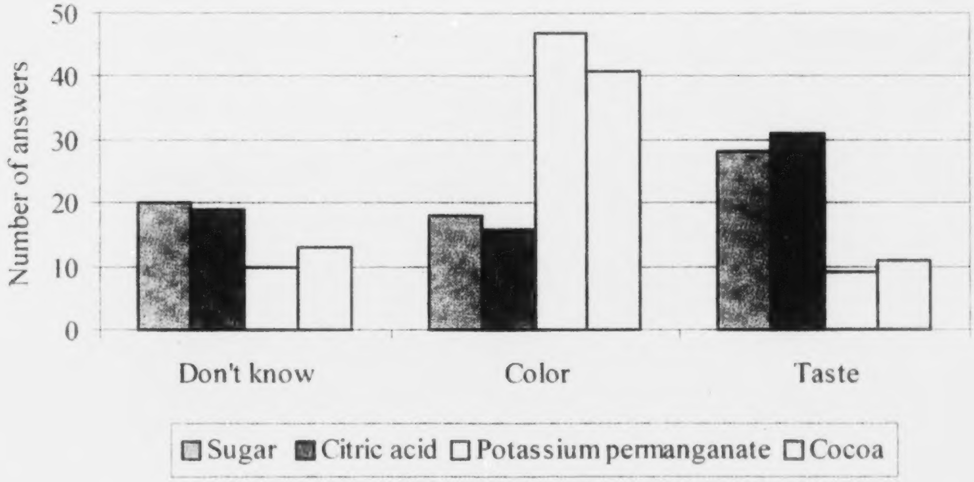

Figure 2. Distribution of answers to the question "What happened with the water?"/

Schoolchildren

The distribution of answers (in percentage) to the question "What happened with the substance?" is given in Figure 1 for both groups. It is seen that few 9-10-year old children gave non-conservation answers. The majority of children (group I) used the terms "melting" and "dissolving" to describe the process of dissolving of sugar. However, children (group II) used the terms "dissolving", "distributing" and "melting" for citric acid. Both groups used "distributing" and "dissolving" to describe the dissolving of potassium permanganate in the water.

While explicitly asked the question "Is the substance still in the water?", in group II 73% children answered affirmatively for citric acid and 77% for potassium permanganate. They explained their conservation-answers similarly to the younger group (i.e. that they saw that the substance had been put into the water). Only three children stated explicitly that the substance stays in the water after it had been put there. Also, three children stated explicitly that the substance had changed or "melted away". However, only 52% of children from group II stated that there was sugar in the water while 90% stated that there was potassium permanganate. Those children who stated that there was no sugar any more either could not explain their answers or said that sugar had changed into sugar-water. The difference between conservation-answers for different questions was significant only for sugar (Q=16.7, p<.001), also the difference in conservation-answers for the explicit question was significant between potassium permanganate and sugar (Q=16.2, p<0=.001).

When talking about what happened to the water, the far majority of children still referred to the changes in colour for potassium permanganate and taste for sugar and citric acid. Only one child said that the substances mixed.

The sequence of tasks had no impact on schoolchildren's results.

Discussion and the implications for teaching

Students learn and understand better the knowledge that can be integrated with their preliminary knowledge and everyday experience (e.g. Schnotz et al., 1999). If the knowledge taught in school differs from students' existing conceptions, different misconceptions arise (Chinn & Brewer, 1993; Driver et al., 1995). Misconceptions arise specifically easily if students' preconceptions are consistently used in various contexts and the new knowledge contradicts them in some ways. These concepts develop as a result of students' attempts to make sense of the new information, making it fit with the preliminary one (see also synthetic concepts, Vosniadou, 1992). Therefore, it is extremely important to know the concepts students hold before the formal teaching starts. In addition, Vygotsky argues that children may use words, taken from adults (from everyday language) but filled with their own meaning (see pseudoconcepts, Vygotsky, 1997). Adults usually think that children have the same meaning as they do, while in reality they have not. To improve science education, the meaning of students' preliminary concepts must be studied in more detail.

The results of the study showed that even as young as 4-year old children have some understanding of the conservation of substances during dissolving, but even 9-10-year olds do not have compact understanding of the process. Interestingly, no differences occurred between 4-6-year old children's results.

As shown before (Au et al., 1993; Rosen & Rozin, 1993), already young children appreciated the conservation of taste of the substance during dissolving. The idea of conservation was not influenced either by the visibility of the process or the familiarity of the substance (cf. Rosen & Rozin, 1993). However, more children explained their answers for familiar (as compared with unfamiliar) substances; these children referred to their experience or that the parents had taught it. But several children stated that the dissolution had the taste of the substance because the substance had been put into the water. To understand that substance conserves (at least some of) its features is important to children in the context of health: it is unhealthy and sometimes dangerous to drink contaminated water (see also Au et al., 1993).

However, children were not so consistent in their answers to other questions. It was found that children understood the dissolving of coloured and white substances differently, but the familiarity of the substance had little influence on the understanding. Kindergarteners appreciated more the conservation of coloured substances (as compared with white substances) after these had dissolved in the water. It is just what is seen: the dissolving of the coloured substance seems like staying in the water while the dissolving of white substances seems like disappearing. Even schoolchildren were inconsistent in their answers: more students stated explicitly that there was no sugar in the water, as compared with those who stated that there was no potassium permanganate.

The main differences, occurring in all the groups, were determined in the word use: the usage depended on the features of the dissolving substance. In all age groups, children used more frequently the word "distributing" to describe the dissolving of visible substances. It seems that the children take use of the visible side: the dissolving of potassium permanganate/cocoa is really seen as the matter distributing in water. Even more, when talking about what happens to the water, children referred to the visible change in the colour, but did not talk about distributing of the substance and the water (cf. Driver et al., 1995; Driver 1985; Lee et al. 1993).

While kindergarteners described the process of dissolving of white substances as "changing" or "disappearing", schoolchildren described it as "dissolving" or "melting" (cf. Krnel et al., 1998; Piaget & Inhelder, 1974; Prieto et al., 1989). The word "melting" is widely used in Estonian in everyday language to describe the dissolving of sugar (e.g., "sugar melts in coffee") (cf. Driver, 1985). Children learn earlier the term "melting": the younger children used it more than the term "dissolving". The older children used more frequently the correct term "dissolving", especially for white substances, but the term "melting" was also used. However, even these children could not explain in other words what they meant by this term. The majority simply stated that they could not explain, others described it as "melting" (for "dissolving") or "dissolving" (for "melting"), but also as "disappearing" and "changing" (cf. Driver et al., 1995; Lee et al., 1993; Prieto et al., 1989). It seems to be the case Vygotsky (1997) described as a pseudoconcept: a word taken from adults but with different meaning and structure. It may be that children think of dissolving as of changing the substance into the new one (e.g., into sugar-water) not as of distributing of the substance and water (cf. Driver, 1985). It was found that children referred to the change in the water's taste (or colour), only one schoolchild talked about mixing.

Our results also showed that children did not have the integrated knowledge of dissolving, which was used consistently for solving different tasks and in different contexts (but see Au, 1994). The results are consistent with the approach of Vygotsky (1997), who states that everyday concepts are perceptually bound and context-dependent, and influenced by the everyday language use. Even the sequence of tasks influenced the results of some tasks in the younger group. Also, in all the groups, the differences occurred between white and coloured substances.

To conclude, it seems that before having learnt the topic in school, children's concepts of the process of dissolving of coloured and white substances may be different. Therefore, it seems important to base in teaching not only on some specific cases (usually, sugar in water) but to give different examples (coloured, white, familiar and unfamiliar substances) and tasks. It was also found that although children use the words melting and dissolving, the meaning of these terms might be different from their scientific meaning. If children's meaning is different from scientific, they interpret the information taught in school differently, consequently, various misconceptions may arise. If dissolving means changing, children think of dissolving as of changing of substance into new one. For sure, the meaning of the words "melting" and "dissolving" needs the further clarification.

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KEY WORDS

Conceptual development, dissolving, conservation, children, science education

Classroom Practices in Secondary Science

Cephas David Yandila, University of Botswana, Botswana
Yandilac@mopipi.ub.bw

INTRODUCTION

Whenever a new or revised school syllabus is introduced in schools, teachers are expected to teach its content according to recommended teaching approach, methods and strategies. This is particularly important where students sit for common national examinations, as is the case in Botswana at the end of standard 7, and Forms 3 and 5.

The new 7-year primary school science syllabus was introduced in schools in 1982 and stipulated that it should be learner-centred and activity-based involving teaching and learning of process skills. The 3-year junior secondary school science syllabus was introduced in schools in 1997 and made similar stipulation with respect to teaching approach, teaching methods and strategies.

The new Botswana Senior Secondary School Science (BGCSE) was introduced in schools in two phases. In phase one, Pure Science of each of Biology, Chemistry and Physics subjects were introduced in 1997. The Single Science made up of one-third each of Biology, Chemistry and Physics and Double Science made up of two-thirds each of Biology, Chemistry and Physics were introduced in January 2000. The basis of offering different syllabuses in each of the three subjects-Biology, Chemistry and Physics was to provide for students with different academic abilities and learning needs. Students who are capable of entering science and science-related fields of study would take Pure Sciences-Biology, Chemistry and Physics and those who are capable of entering technical fields would take Double Science. But those who are not capable of entering either academic or technical fields of study would take Single Science to acquire scientific literacy, expected of all citizens who complete secondary education.

Each science subject offers core content that every student takes and an extension content that only students who are academically strong may take in addition to the core. This arrangement of the syllabus, caters for students with different learning styles and needs. As in the case of the new primary school science and junior secondary school science, the significant feature of the new senior secondary school science syllabus is its recommended teaching methods that are learner-centred and encouraging problem-solving and hands on approaches (Republic of Botswana, 1997, 2000).

From the time the syllabuses were introduced in schools, no study has been carried out to find out how effectively they are being implemented by science teachers. The purpose of this paper was to find out the extent to which senior secondary school teachers were employing the recommended teaching methods and approaches in teaching Pure, Double and Single Sciences.

Research Design

The study involved classroom observation using a checklist whose content was based on the prescribed teaching methods and approaches. It was a non-participant 'fly on the wall' observer. This is a situation where the observer sits at the back of the class seemingly aloof from class activities and records class activities without participating in the proceedings.

Population and Sample

The population of the study included all 27 senior secondary schools. Three qualified science teachers were each randomly selected whose lessons were to be observed by a trained research assistant. Of the 85 completed observation checklists, there were 48 biology, 22 chemistry and 13 physics lessons observed.

Instrumentation

Several scholars have developed different instruments to record classroom observations. Since there is no single instrument that can be used in every circumstance, the research took Bell's (1999) admonition to devise an appropriate one.

In this study, the Class Observation Checklist consisted of a fixed number of competencies listed in the new science syllabus. It was developed by drawing information from various sources, including the instruments used for assessing student teachers at the University of Botswana, in colleges of education in Botswana and literature such as Walters (1993), Duminy, et al (1992). Twenty-seven competencies were identified and placed into three major categories of Administrative, General Professional and Teaching. Administrative competencies related to planning and managing of teaching materials and consisted of six sub-categories. General professional competencies related to the teacher's appearance, attitudes towards students, school authorities and response to students' complaints about his or her treatment of them. It consisted of three sub-categories. Teaching competencies consisted of 17 sub-categories covering a wide range of classroom activities that the teacher and students might undertake.

Under each sub-category, several checklist questions were raised, soliciting a "Yes" or "No" response to be completed by the classroom observer. A "Yes" response would indicate that the teacher in the course of the lesson had demonstrated that particular competence, at least once. A "No" response would indicate that the teacher had not demonstrated that particular competence during the lesson.

Administration of the instruments

The classroom observation checklists were completed by 40 student teachers doing supervised school-based teaching practice in 27 secondary schools in Botswana. They were all trained in how to complete the checklists while observing science lessons in schools. Each observer made prior arrangements with the selected teacher to observe his or her lesson. The purpose of the observation was explained. On a scheduled date and time, the observer entered the class as non-participant observer. While sited at the back of the class, the observer noted what the classroom teacher brought to the class and the actual class proceedings from its start to the end. The duration of the lessons was either 40 or 80 minutes long. The competencies were checked as the lesson progressed. The observer left the class after it was completed, and mailed it to the researcher for analysis.

Analysis of Data

Eighty-five completed checklists were received from classroom observers. The numbers of "Yes" and "No" on each of 27 competencies were counted and percentages computed. They were presented in 12 competencies, namely: Administrative and Planning, General Professional, Question and Answer, Communications, Audio-visual Aids, Subject Matter, Lesson Flow, Demonstration, Meeting Learning Needs of Different Students in Class, Student Practical, Assessment, and Application to everyday life. The means of percentages of competencies were presented in the Tables 1-12 below, each preceded by its description.

Results in Table 1 show that in general, 55% of teachers did not demonstrate the required administrative/planning competencies during lesson observation and 45% did. The percentages of teachers who did not bring the documents or materials and therefore not use scheme of work, teaching file, lesson plan, lesson notes and teaching aids were 61%, 57%, 55%, 48% and 56% respectively. According to the new syllabus, science teachers are required to make adequate preparations for their lessons in the form of these documents. Their absence in class may suggest that the teacher concerned did not adequately prepare for the lessons

Table 1 showing Frequencies Administrative/ Planning Competencies in Lessons

Administrative /Planning Competency	Yes	No
1. Scheme of Work	39% (33)	61% (52)
2. Teaching File	43% (37)	57% (48)
3. Lesson Plan	45% (38)	55% (47)
4. 4. Lesson Notes	52% (44)	48% (41)
5. Teaching Aids	44% (38)	56%(47)
	45% (38)	**55% (47)**

The results in Table 2 indicated that overall, 53% of the science teachers demonstrated acceptable general professional competencies in appearance, grooming, attitude, enthusiasm and interest in their students and had good relationship with their students. However, only 6% of the teachers responded to students' complaints about the way they taught. This may suggest that students did not feel free to express their concern, as the lessons were teacher-centred.

Table 2 showing Frequencies of General professional Competencies in Lessons

General Professional Competencies	Yes	No
6. Teacher's Appearance-grooming/dress/hygiene	80% (68)	20% (17)
7. Teacher's Professional Attitude, enthusiasm or interest to students, school authority or syllabus	73% (62)	27% (23)
8. Responses to students' criticism or complaint about the way he or she does things	6% (5)	94% (80)
10. Relationships with students	53% (45)	47% (40)
	53% (45)	**47% (40)**

The results in Table 3 indicated that on average, 66% of the teachers demonstrated the competencies of asking and answering questions during science lessons and 34% did not. This suggested that the teachers concerned dominated the lesson allowing little or no questions from the students and not asking questions. Preliminary results of a current study have revealed a number of reasons why students do not participate in question and answer discourse in class. Some of them are fear of being ridiculed by peers, fear of exposing their ignorance to their teachers and peers, difficulty to speak in English, failure to understand the teachers' questions due to poor language barrier, disinterest in the lesson. The new syllabus encourages the question and answer discourse in class so those teachers may attend to misconception and learning difficulties of students.

Table 3 showing Frequencies of Question and Answer Competencies in lessons

Question and Answer Discourse Competencies	Yes	No
11 Questioning Skills	55% (47)	45% (38)
12 Answering skills to students' questions	77% (66)	23% (19)
	66% (57)	**34% (28)**

Table 4 showed that almost all the teachers communicated verbally with their students and 44% used body language such as moving hands, shaking head and kicking with legs. In a teacher-centred lesson, voice communication was expected.

Table 4 showing Frequencies of Communications Competencies in lessons

Communications	Yes	No
14 Voice Communications	99% (84)	1% (1)
15. Body Communications	44% (37)	56% (48)
	71% (60)	**29% (25)**

Table 5 showed that overall, 64% of the teachers did not use audio-visual teaching aids. They relied on the voice communications, shown in Table 4 above. The new syllabus encourages the use of different teaching aids to help students comprehend the content. Failure to use teaching aids could not be due to their absence because they were provided for in every senior secondary school in the country.

Table 5 showing Frequencies of Competencies in Audio-visual Aids in lessons

Use of Audio-visual Aids	**66% (57)**	**34% 28)**
16. Use of Audio Aids	5% (4)	95% (81)
17. Use of Visual Aids	40% (34)	60% (51)
19 Use of equipment	40% (34)	60% (51)
	36% (30)	**64% (55)**

Table 6 showed that 42% of the teachers did not demonstrate mastery of their teaching subject. This may be related to inadequate preparation of scheme of work, lesson plans, and lesson notes, teaching aids. Perhaps such teachers were overconfident that they knew it all so that they did not need to prepare for their lessons. This may result from long teaching experience. It should be noted that the content of the new syllabus is different from the old COSC syllabus. Long serving teachers need to acquaint themselves with it just as new teachers

Table 6 showing Frequencies of Competencies in Subject Matter in lessons

Mastery of Science Content	**Yes**	**No**
13 Teacher's mastery of the subject matter being taught	58% (49)	42% (36)

Table 7 shows that 72% of the teachers did not have their lesson flow well. This further supports the need for teachers to prepare well for their lessons.

Table 7 showing Frequencies of Lesson Flow in lessons

Lesson Flow	**Yes**	**No**
7. Lesson Flow	28% (24)	72% (61)

Demonstration is one of the recommended teaching methods in the new science syllabus. But the results in Table 8 shoed that only 42% of the teachers employed it in their lessons. This was unsatisfactory.

Table 8 showing Frequencies of Demonstration Competencies in lessons

Demonstrations	**Yes**	**No**
21. Teacher Demonstrations	58% (49)	42% (36)

The results in Table 9 showed that 46% of the science teachers did not employ mixed ability teaching strategy prescribed in the new syllabus.

Table 9 showing Frequencies of meeting the learning needs of different students in class

Meeting the learning needs of different students in class	Yes	No
23. Mixed ability teaching	54% (47)	46% (39)

Table 10 showed that only 64% of the science teachers demonstrated the practical work competencies during the lesson. Specifically, 47% were inculcating in students the skills of using and organising techniques, an apparatus and materials; 72% were inculcating the skills of observing, measuring and recording; 55% were inculcating the skills of handling, experiments and data; and 42% were inculcating the skills of planning investigations. Considering the insistence of new science syllabus on inculcating the four experimental skills in students, the percentages of occurrence in the lessons observed should be considered too low. The overall percentage of 44% of teachers who did not demonstrate the four experimental skills was therefore, too low.

Table 10 showing Frequencies of Student Practical Work in lessons

Student Practical Work	Yes	No
22. Student Practical Work	64% (54)	36% (31)
24. Using and organising techniques, an apparatus and materials	47% (40)	53% (45)
25. Observing, Measuring and Recording Skills	72% (61)	28% (24)
26. Handling skills, experimental observations and data	55% (47)	45% (39)
27. Planning skills in investigations	42% (36)	58% (49)
	56% (48)	**44% (37)**

The results in Table 11 showed that one third of the science teachers did not assess students' work by either handing back marked work or giving assignment at the end of the lesson. Formative assessment of student work is highly recommended in the new syllabus. Its absence in class was not a good sign of how the new syllabus was being implemented in schools.

Table 11 showing frequencies of Assessment of Students' work in lessons

Assessment of student work	Yes	No
28. Assessment provided or returned to students	67% (57)	33% (28)

Table 12 showed that only 47% of the teachers discussed the application of the topic to the students' everyday life. This was also recommended in the new syllabus.

Table 12 showing Frequencies of Application to everyday life in lessons

29. Application to everyday life	Yes	No
30. Application of the topic to everyday life	53% (45)	47% (40)

DISCUSSION

The results of this study suggested that the recommended teaching methods and approaches were not being fully followed by most science teachers. The majority of the lessons did not seem to encourage a learner-centred approach as emphasised in the curriculum blueprint. The teachers dominated in class activities with little student participation, except in question and answer discourse and during demonstration.

Mixed ability teaching, which encourages students with different academic abilities, was evident in some lessons. However, its absence in 46% of lesson was consistent with the findings in primary school and junior secondary school lessons reported by Tabulawa (1995), Madome (1998), and Letsholo (1996). Mixed ability teaching was adopted science in Botswana and schools were directed to employ it by the Ministry of Education (Revised National Policy on Education, 1994; Curriculum Blueprint, 1997). For this reason, it was expected to be practised in all science lessons. It was no longer an option for teachers to employ because students entering senior secondary schools had a variety of learning abilities. According to Armstrong (1994) and Visser (1993) the students may have multiple intelligence which can only be addressed if lessons are differentiated.

The new syllabus recommends that science teachers should plan for their lessons. Such planning would be manifested in the scheme of work, teaching files, lesson plans, lesson notes, and teaching aids. Most teachers did not bring such documents to the class.

In the absence of good planning for science lessons, one wonders whether teachers could be said to be effective teachers who embodied the positive characteristics of a teacher as a colleague, a facilitator, a manager and a transmitter? To what extent could a science teacher be said to demonstrate what Shulman (1986) calls pedagogical reasoning that involves a cycle activities starting with comprehension, transformation, instruction, evaluations and new comprehension. These, particularly reflection, cannot be adequately examined if the teacher did not make adequate plans for science lessons.

The new syllabus encourages inculcating the process skills in students to be reflected in the (i) using and organising techniques, and apparatus and materials, (ii) observing, measuring and recording, (iii) handling, experimental observations and data, and (iv) planning investigations. Associated with these skills are the seven major processes of science identified by philosophers of science as recognition of a problem or a puzzle, formulation of working hypotheses, collection of relevant data, verification of the claims of the hypotheses, deduction from postulated hypotheses, induction from collected data, testing predictions against empirical facts and modification, acceptance or rejection of a new theory based on empirical evidence

The results showed that in only 56% of the lessons observed were the four process skills demonstrated. There may be several explanations for these results. Out of 27 senior secondary schools only four new schools had functional laboratory facilities. Due to expansion drive, laboratories in the rest of the schools were undergoing major renovations at the time this study was undertaken. After the renovations were completed, science teachers would not use the absence of the laboratories as an excuse for not allowing students to do practical work during the lessons.

Science teachers should not forget that by denying students practical work in science denies them the acquisition of the most needed ethics of science such as openmindedness, inventiveness, objectivity, integrity, initiative, concern for accuracy and precision. There may be other reasons why teachers did not carry out student practical work. Rammung (2000) found that teaching large classes, having large teaching loads, and lack of adequately trained laboratory assistants were reasons why teachers did not employ learner-centred approach.

The new syllabus recommends that teaching methods should expose learners to practical applications of science in everyday life. This is not being followed in school science. It recommends that a variety of teaching methods should be used in the teaching and learning of school science e.g. inquiry, demonstration, practical work, project work, case study, field trips, discussions, computer guided learning etc. Most of these methods were not evident in the lessons observed. It is alleged that most teachers believed that if they tried different teaching methods they would not be able to complete the syllabus in time for students to prepare for the final examinations at the end of Form 5. For this reason, they resorted to teacher-centred lecture method dominated with giving of notes, running demonstrations. Students do some practical work as a drill preparing for final practical examinations.

If Armstrong's (1994) description of the seven different learning styles of students are taken seriously, then employing a variety of teaching methods is likely to benefit more students in a class than to use one or two methods. This is because students who have one type of intelligence are motivated to learn in a particular manner. For example a student who is strongly linguistic thinks in words; logical-mathematical, thinks by reasoning; spatial, thinks in images and pictures; bodily-kinaesthetic thinks through somatic sensations; musical, thinks via rhythms and melodies; interpersonal, thinks by bouncing in other people; and intrapersonal, thinks deeply inside themselves. Each of these types of students has specific learning needs

RECOMMENDATIONS

1. The Departments of Secondary Education and Curriculum Development & Examinations Units in conjunction with Senior secondary schools should motivate science teachers to fully adopt the recommended teaching orientation and methods of science syllabuses.
2. Senior secondary schools should create conducive environments for science teachers to teach science in accordance with syllabus stipulations.
3. A more comprehensive investigation should be undertaken to find out causes of the disparities between classroom practice and theory in secondary science.

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Analogies and Metaphors as Tools for Explaining Science: Greek Physics Textbooks for the 8th Grade

Vasilia Christidou, University of Thessaly, Greece
ilia@the.forthnet.gr
Vasilis Koulaidis, University of Patras, Greece
koulaidi@upatras.gr

1. INTRODUCTION

When people are faced with scientific knowledge, they relate new information to their relevant existing knowledge, constructing their own representations. Successful learning depends upon the capacity of the learner to identify the appropriate pieces in his/her already existing knowledge base and use them as starting points for the acquisition of new knowledge.

Analogies and metaphors are cognitive mechanisms that provide a means for understanding the structure of unfamiliar conceptual domains. Their common characteristic is the juxtaposition of two different conceptual systems (referents), i.e. the familiar, *base domain* and the unfamiliar, *target domain* that the analogy (or metaphor) aims to explain. Thus, metaphors function as tools of thought. People use them spontaneously in their discussions of natural phenomena, in order to structure unfamiliar knowledge domains.

Metaphorical and analogical reasoning can facilitate the construction of new schemata and make the knowledge base more flexible, since they provide a rational bridge from a familiar to an unknown domain of considered knowledge, by combining different contexts of understanding (Petrie, 1979). Metaphors and analogies are tools of explanation typically used by novices who lack general rules or schemata, and by children who use it as a primary knowledge acquisition mechanism (Vosniadou & Ortony, 1989).

In science teaching metaphors and analogies are usually used as means (tools) of explanation. They introduce a conceptual domain considered familiar to the students (the base domain) in order to describe and render understandable a scientific concept or theory (the target domain). The transfer of information from the base to the target domain often provides a more substantial and effective mechanism of understanding than, for example, the application of known rules, or the use of mathematical formalism.

In this presentation we consider analogical and metaphorical thinking as serving common goals in everyday understanding as well as in the development of scientific theories, or in science teaching. However, a distinction between metaphor and analogy is necessary for the present analysis.

There is no sharp distinction between metaphor and analogy. However, this distinction depends on the degree to which the two referents differ. In the case of metaphors there are fundamental differences between the referents whereas referents that possess more similarities than differences are analogies (Vosniadou, 1989).

The distance between base and target domain in a metaphor causes semantic anomaly emanating from the juxtaposition of contradictory referents. This semantic anomaly can be interpreted and become meaningful. On the other hand every metaphor comprises analogies between the referents, otherwise it is not intelligible. Analogies are not characterised by semantic anomaly. They explicitly stress the similarities existing between the two referents.

Reducing a metaphor to an analogy emphasises the similarities among the referents and diminishes the dissimilarities. Thus an analogy is explicit and highly focused on the similarities of the referents, while a metaphor is more suggestive and creative, due to the existence of dissimilarities among the referents, or its paradoxical character.

Thus, some degree of similarity between the two referents is a necessary but not sufficient condition for the existence of a metaphor (Mac Cormac, 1985).

For the sake of our analysis we consider as an analogy any explicit statement involving a quadripole of four concepts – nodes (illustrated in Figure 1): two concepts (b_1 and b_2) connected by a known relation (R_1) in the base domain and two concepts (t_1 and t_2) connected by a similar relation (R_2) in the target domain (Gentner & Gentner, 1983; Halford, 1993).

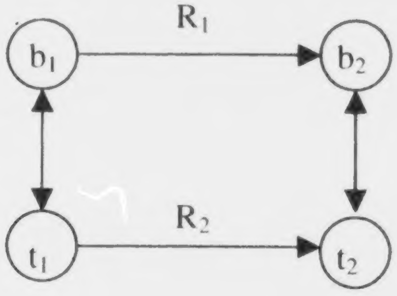

Figure 1: Schematic representation of an analogy

Analogical reasoning involves transferring structural information form the base to the target domain (Vosniadou, 1989).

The use of analogies in science teaching has become a field of increasing interest, since there seems to exist a considerable correlation between analogical reasoning and the construction, selection and use of mental models.

The way a science textbook is written influences the way science teachers teach, as well as the way students learn. Thus, science textbooks play an important role in teaching and learning science in the school context. In this perspective, their analysis in respect to the use of analogies and metaphors can illuminate the processes, content, and sequence of activities that characterize science lessons (De Posada, 1999).

The aim of this paper is the identification and classification of the analogies and metaphors used in the Greek physics textbooks for the second grade of the Greek gymnasium. The new curriculum allows the teacher to choose between two textbooks that were published this year. The two textbooks examined cover the same subject matter, organised in five chapters, which are: 1) An introduction to science; 2) Heat; 3) Optics; 4) Electromagnetism; 5) The structure of matter (atoms and molecules). Each chapter is organised in different units.

2. Methodological framework

Analysis of analogies

Analogies were isolated in the two textbooks. The elements belonging to the base and the target domain were identified and a quadripole (according to figure 1) was constructed for each analogy, involving concepts, relations, and characteristics. In some cases there was more than one analogical structure connecting the base and the target domains (multiple analogies). These multiple analogies were developed in more than one simple quadripoles.

The scheme of analysis for the analogies comprises the following five dimensions:

1. Horizontal completeness. An analogy is horizontally complete if all the elements (concepts and relations) in the base and the target domains are represented. Alternatively, one or more of the quadripole elements may be missing from the base and/or the target. A good explanatory analogy should be horizontally complete.

2. Vertical completeness. This dimension refers to the explicit correspondence between each node (concept) of the base domain to one node (concept) of the target domain. Analogies may be a) vertically complete, or b) lacking one or more correspondences (or corresponding concepts). Vertical completeness is very important for the clarity of an analogy.

3. Systematicity. The quality of an analogy depends on the correspondence between the relations of the base and the target domain. An analogy is systematic when the relations mapped in the base and the target domains are similar/uniform, or form a higher order structure. Three types of analogies were identified according to this dimension: a) systematic analogies, b) analogies with similar relations and different details (characteristics, attributes, examples), and c) analogies with different relations in the base and the target domain. Only horizontally complete analogies are examined in regards to this dimension.

4. Appropriateness of the base domain. When using analogies in science teaching one should make sure that the structure of the base domain is familiar to the students, so that they can map it to the target. The use of an unfamiliar conceptual domain as a base can produce inappropriate mappings in students' thinking and inadequate understanding of the target. The analogies identified in the textbooks were classified as having a) a familiar base, b) a moderately familiar base, or c) an unfamiliar base.

5. Conceptual distance of base and target, concerning the ontology of the base and the target nodes. Each of the four nodes (concepts) can either belong to Group A involving specific entities (usually with material substance, such as objects, substances, persons, or containers), or to Group B, involving abstract concepts (such as phenomena, scientific processes, or scientific concepts). An analogy is characterised as having a) a large ontological distance if the nodes of the base belong to one group (e.g. Group A) and the nodes of the target to the other (e.g. Group B), b) moderate ontological distance if the base and/or the target involve concepts from both Group A and Group B, or c) small ontological distance if the four nodes of the analogy belong to the same ontological category (e.g. Group A).

Analysis of metaphors

The analysis of metaphors involves three dimensions:

1) The *ontological basis* of metaphors, i.e. the ontology of the base domain, which involves the following ontological categories:
    a) *Objects*, identified as having clearly specified and directly perceptible limits;
    b) *Containers*, also bounded by a surface, having an in/out orientation and the capacity to hold other things inside;
    c) *Substances*, usually used in order to render understandable activities, or concepts involving a sense of evolution, or 'flow';
    d) *Persons*, imposing human terms (such as motivations, goals, actions and characteristics) to unfamiliar concepts and
    e) A *general category* comprising various other conceptual categories (including places, activities, classes of material things, scientific concepts, and states), not frequently used in the texts.
2) The *density of metaphors* (number of metaphors per page) per unit, i.e. which subjects are most (and least) readily presented with the use of metaphors;
3) The *patterns of ontological description* used to describe the central scientific terms in the textbooks. These terms include i) science, ii) electric charge, iii) light, iv) energy, v) force, vi) magnets, vii) molecules, and viii) atoms.

3. Results

Analogies

Textbook A (Karapanagiotis et al., 1998) comprises 22 analogies and 556 metaphors. Furthermore, 6 of the analogies are multiple, thus they are developed in more than one quadripoles. The total number of quadripoles identified in Textbook A is 31.

Textbook B (Antoniou et al., 2000) comprises 9 analogies and 475 metaphors.

Table 1 illustrates the number of analogies per chapter in the two textbooks.

	Introduction to science	Heat	Optics	Electromagnetism	Structure of matter	Total
Textbook A	1	2	2	3	14	22
Textbook B	0	3	1	2	3	9

As can be seen in Table 1, there is a clear difference in the frequency and the distribution of analogies between the two textbooks. Textbook A introduces a limited number of analogies concerning the first four chapters, but uses a remarkable number of analogies in the chapter referring to the structure of matter. On the other hand, the analogies in Textbook B are few and rather uniformly distributed in the five chapters[1].

The analysis of analogies along the five dimensions presented above, has concluded to the following (see Table 2):

Table 2: The analogies analysis results for Textbook A and Textbook B

	Horizontal completeness		Vertical completeness		Systematicity			Appropriateness of base			Ontological distance		
	com.	inc.	com.	inc.	s.	d.a	d.r.	f.b.	m.f.b.	u.b.	s.	m.	l.
Textbook A	22	9	7	24	10	9	3	10	13	8	10	7	14
Textbook B	5	4	1	8	2	2	1	4	3	2	1	5	3

a) In regards with *horizontal completeness*, complete analogies prevail in Textbook A, while they are almost as frequent as incomplete analogies in Textbook B. An horizontally incomplete analogy is one that lacks one (or more) nodes and/or relations of the quadripole.

b) The majority of analogies in the two textbooks are *vertically incomplete*: they do not establish explicit correspondences between each node of the base domain with one node of the target domain.

c) Analogies are not always *systematic*. In Textbook A analogies introducing different attributes are nearly as frequent as systematic analogies, while there is a considerable number of analogies involving different relations in the two referents. In Textbook B systematic analogies are as frequent as analogies with different attributes, while one analogy involves different relations.

d) Not all analogies introduce an *appropriate* (i.e. familiar) *base* domain. In textbook A most of the analogies introduce a moderately familiar base, closely followed by the analogies with a familiar base and the ones with an unfamiliar base. Textbook B introduces more analogies with a familiar base domain, followed by the analogies with a moderately familiar base and the ones with an unfamiliar base. However, the differences in frequencies are not noteworthy.

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[1] A point should be made here: In Textbook B it is very common that physical phenomena, like thermal expansion, are explained through the use of the particle theory.

e) In Textbook A analogies with large *ontological distance* prevail over the analogies with small ontological distance, and the analogies with moderate ontological distance (including nodes from two different ontological groups in the base and/or the target domain). Most of the analogies in Textbook B, however, are characterised by a moderate ontological distance, while there are some analogies with large ontological distance and one analogy with small ontological distance.

Metaphors

Metaphors are widely used in both Textbooks. Table 3 presents the distribution of the metaphors per chapter in Textbook A and Textbook B, according to their ontological basis.

As can be seen, the vast majority of metaphors used in the two textbooks are personifications, i.e. scientific entities or phenomena are described and explained in human terms. The ontology of objects is quite frequently introduced. The ontological category of substances is the third preference; the super-category comprising various other conceptual categories comes fourth, while the category of containers is the least preferred.

Table 3: Number of metaphors per chapter in Textbook A according to ontological category.

	Introduction to science	Heat	Optics	Electromagnetism	Structure of matter	Total
object	11	20	44	45	40	160
container	5	4	13	14	11	47
substance	4	8	14	33	7	66
person	35	108	200	223	140	706
various	13	15	6	11	7	52
Total	68	155	277	326	205	1031

Moreover, the distribution of metaphors in the five chapters of each textbook is not uniform. The difference is more apparent in Textbook A, where electromagnetism is the subject where metaphors are most frequently used, closely followed by optics. Similar tendencies appear in Textbook B, where metaphors are as frequently used in discussing optics as in discussing the structure of matter.

The non-uniform distribution of metaphors is also remarkable within the chapters. The density of metaphors (i.e. metaphors per page in each unit) ranges from 0 to 10 in Textbook A and from 0,1 to 12 in Textbook B. Table 4 illustrates the units with the lowest density of metaphors for each textbook, while Table 5 illustrates the units with the highest density for the two textbooks.

Table 4: Units with the lowest density of metaphors

	Title of unit	Density of metaphors
Textbook A	Thermal expansion and contraction	0
	Melting and congealing	0
	Density	0
	Measuring physical quantities	0,3
	The International System of units	0,3
Textbook B	Introducing the laboratory - measurements	0,1
	Introducing the magnetic force	0,5
	Heat: a form of energy	0,7
	How do we measure heat?	0,7
	How we interrogate nature: The scientific method	1

Table 5: Units with the highest density of metaphors

	Title of unit	Density of metaphors
Textbook A	Light and energy	10
	Leaps of electrons	10
	Refraction	8,3
	Crystallic lattices and properties	6,7
	The electromagnet	5,3
Textbook B	Atom and light	12
	Bonding between atoms and between ions	9,6
	Applications of electromagnets	9,6
	A different journey [the structure of matter]	8
	Molecules and atoms	7,8

As far as the last dimension of the metaphor analysis is concerned, i.e. the *patterns of ontological description*, textbook analysis concluded to the following outcomes:

i. *Science* is primarily described as a person, while less frequently it is presented as a building (construction), as an adventure, or as language. For example:

"Physics is the most traditional science, *studying* the physical world, by *putting questions* and *giving answers*" (ontology of person, Textbook A, p. 20).

"The study of physics is an *exciting adventure*" (ontology of adventure, Textbook B, p. 7).

ii. *Energy* (and *heat*) is described as a merchandise, or as a substance, and rarely as a person, vehicle, or object. For example:

"In our culture, energy is an *article of commerce*. [...] we should use it without *wasting* it" (energy as merchandise, Textbook A, p. 70).

"[The sun] is the primary and most important *source* of energy for [the Earth]" (energy as a substance, Textbook B, p. 83).

iii. *Light* is vastly approached in human terms (personification), and less frequently as a vehicle, object, or substance. For example:

"[...] we will study how a beam of light *behaves* when it *passes* from one transparent body to another [...]" (ontology of person, Textbook B, p. 99).

"The light is *bended* (refracted)" (ontology of object, Textbook A, p. 149).

iv. *Magnets* are almost exclusively approached in human terms. For example:

"The magnetic needle is *orientated* in the direction of north-south" (magnet as person, Textbook B, p. 128).

"The north magnetic pole (N) of the magnetic compass *points* in the direction of the geographical North Pole, close to which the magnetic south pole is found" (magnet as person, Textbook A, p. 196).

v. *Force* is described through the use of personifications:

"[...] electric forces *hold* the molecules tightly close to one another" (force as person, Textbook A, p. 275).

vi. *Molecules* are mainly described as persons, and less frequently as objects, containers, or buildings. For example:

"In iron every molecule is joined [...] with its *neighbouring* [molecules]" (ontology of person, Textbook B, p. 56).

"An insulator's molecules *contain* both positive and negative particles" (molecule as a container, Textbook B, p. 143).

vii. *Atoms* are described as persons, objects, or containers. For example:

"Each of the atoms can *'dispose'* of one electron [...] the pair of electrons *belongs* to both atoms" (atom as person, Textbook B, p. 178).

"Dalton imagined atoms like invisible, small, rigid *spheres*" (atom as object, Textbook A, p. 272).

viii. *Electric charge* is primarily described as a person, or as a fluid (when discussing electric current), and less frequently as an object. For example:

"[...] charged particles *move* [...], *following* specific *paths*" (electric charge as person, Textbook B, p. 153).

"[...] a *flow* of electric charge through conductors, which we call *electric current*" (electric charge as fluid Textbook A, p. 236).

"We conclude that electric charge appears in *'small parcels'* that we call quanta" (electric charge as object, Textbook B, p. 148).

4. Conclusions and implications

The previous analysis shows that there are similarities as well as marked differences in the way the two new physics textbooks for the 8th grade treat analogical and metaphorical speech as a tool of explanation.

There is a difference in the frequency analogies are used in the two textbooks. Textbook A does a much more extensive use of analogies than Textbook B. Furthermore, most of the analogies in Textbook A are located in the chapter referring to the structure of matter. In Textbook B analogies are rarely used and are rather uniformly distributed. A possible explanation of those differences in the use of analogical thinking may be that in Textbook B one of the primary schemes of explanation is the model of the structure of matter, used for approaching various different phenomena, in most of the chapters. On the other hand, in Textbook A the structure of matter is only discussed in the corresponding chapter, and is not used in the previous chapters in order to explain macroscopic phenomena.

The explanatory potential of analogies is not fully exploited in the two textbooks. An appropriate analogy for teaching science should have horizontal and vertical completeness, systematicity, an appropriate (familiar) base, and large ontological distance. This is not the case for the majority of analogies, especially in regards to vertical completeness, systematicity, appropriateness of base and ontological distance.

Metaphors are much more extensively used than analogies in the two physics textbooks. There is a strong preference to personifications, over the other categories, using the ontological basis of object, container, substance, or the super-category of various other concepts.

The metaphors are not uniformly distributed in the five chapters. Electromagnetism and optics (as well as the structure of matter in Textbook B) are the subjects most frequently described through the use of metaphors. The same tendency is fairly pronounced even within chapters. Units referring to the physics laboratory, measurements, or physical quantities, tend not to use metaphors, while units referring to particles, refraction (in Textbook A), or electromagnets exhibit the highest frequency in the use of metaphorical speech.

The textbooks analysed seem to treat specific scientific terms in a rather systematic way. There are patterns of ontological description, i.e. each term is usually described through the use of a specific ontology. Thus, science, light, magnets, force, molecules, atoms, and electric charge, are primarily treated in human terms (personifications), while energy is most frequently approached as a merchandise, or a substance. Alternatively, science can be viewed as a construction, adventure, or language, light can be viewed as a vehicle, object, or substance, molecules are described in terms of objects, containers, or buildings, atoms as objects or containers, and the flow of electric charge in terms of a fluid substance.

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How Do Students Learn to Make Informed Decisions?

Angeles Gómez Niño, Yolanda Padilla,
Antonio Carretero, and María J. Sáez
University of Volladolid, Spain
mariajsaez@retemail.es

INFORMATION ON THE PROJECT

The European Initiative for Biotechnology Education (EIBE) has been working since 1991 to promote public understanding of biotechnology through raising awareness and understanding among the youngest, because they are a receptive target group to the topic and will enter into informed public debate in the near future. EIBE develops and produces teaching materials, strategies and expertise for science and non-science teachers, providing through a thematic approach contexts for exploring scientific and technological topics associated with relevant economic and societal issues in authentic learning situations.

Founded in 1991, EIBE has become an active European multidisciplinary network of some 40 experts in biotechnology education drawn from 25 centres in 18 European countries, including four east European countries. EIBE is currently participating in the EU Framework IV Biotechnolugy Programme through a Concerted Action Project.[2]

The EIBE units are organized as a bank of resources and focus on the following topics: Inmunology, food biotechnology, medical biotechnology, fermentation, human genoma, transgenic plants and animals.

Within the frame of the development of the EIBE Project in Spain, four case studies have been carried out. They correspond to the four EIBE units implemented in Spain. During the first stage of the fieldwork (1997 and 1998) , the Spanish research team considered the possibility of a specific project on "Identification and treatment of the values of the teaching-learning of biotechnology". This project was financed by the Spanish Ministry of Education during the school years 1998-99 and 1999-2000.

After an overview of the general outcomes in this paper presents one of the main findings of the project: what are the teaching conditions that influence teaching-learn-

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1. Dpto. Did_ctica Ciencias Experimentales, Facultad de Educaci_n, C/ Francisco Hern_ndez Pacheco, 1, 47009 Valladolid, Spain; e-mail: mariajsaez@retemail.es

2. For further information contact the EIBE Co-ordinator Prof. Dr. Horst Bayrhuber, Institute for Science Education (IPN) at Kiel University, Olshausenstrasse 62,

24098 Kiel, Germany

EIBE Secretary: Renate Glawe Phone +49 4318803132 Fax +49 4318805353 ing strategies regarding socially controversial topics – as is the case with the topics of biotechnology – so that pupils succeed in making informed decisions effectively? Or, in other words, under which conditions students can make informed decisions?

METHODOLOGY

Case studies are a common approach in research for the social sciences as well as in evaluation (Smake 1978). Smake (1995) points out that researchers using case studies as their research strategy tend to adopt a number of different roles in the studies they undertake. The writer of an evaluation case study will use specific criteria or a series of interpretations to help bring the weaknesses and strengths of the program under consideration to the forefront. The qualitative evaluator (Lincoln & Guba 1985; Guba & Lincoln 1981) will underline the quality of activities, and - in so far as she/he sees the latter as processes - she/he will present them in the form of narratives of a descriptive, analytic and interpretative type. Stake (1995) points out also that researchers choosing the case study approach adopt a number of different roles in the studies they conduct. These roles may have to do with research (interpreters), expert advice (consultants), training (teachers), biography (narrators), evaluation (assessing merits and values: evaluators). We explicitly assumed the role of researchers, since we approached each classroom in the hope of not only fully understanding what was going on in the biotechnology lessons, but also of using this ethnographic exercise as a means of analyzing and assessing the nature of innovations implemented in each of the biotechnology topics and their relation to the process of change entailed by the introduction of the new curriculum.

Writing case studies with a naturalist methodology means that the educational fact is described in its context, and that it has to be feasible and easy to recognize by those acquainted with the classroom's reality. The reader must also be able to clearly distinguish those phenomena that are specifically linked to the peculiarities of the topic from those that go far beyond such limits and are generally related to the subject of education. As we have already pointed out, this understanding of what a case is about lies very close to constructivist positions (Wells et al., 1995), according to which it is a social construct. This means that the case is not defined until the collection of data is finished and the analysis is well on its way. Our manner of building up the case, therefore, is similar to this constructivist approach which stresses the idea of the collaborative construct.

The categorization and processing of data would allow us to distinguish the one from the other: from the total amount of data obtained from each classroom we had to discern those which were essentially idiosyncratic or specifically related to the contexts they belonged to; but, at the same time, we had to be on the look-out for broader patterns that may initially be considered the result of implementing innovation in science curriculum (general features), as a comparison of different classrooms in other schools would make apparent. Likewise, we would trace those aspects associated to any process of school change.

The fieldwork, implemented through immersion in the field for short but intense periods of time, was naturalistic in nature, examining what happens in schools and classrooms from many perspectives, without direct intervention by the researchers. This methodology (S_ez & Carretero 1995, 1998a; Simons 1996, 1997) gave us the opportunity to 'catch the feeling' of the 'lived' innovation. The naturalistic nature of the study allowed us to produce detailed descriptions of what happened from the point of view of the persons taking part in the process, with the result that we were able to capture the innovations as they were experienced by teachers and students. The method of analysis was an inductive exercise of the collaborative work of the research team.

Our experience with case studies has made us use precise terminology according to which the different types of study can be distinguished (S_ez & Carretero, 1994). First we have the type we initially used and which we call "methodological", because it aims at becoming a way of storing the information obtained and arranging it in a meaningful way. "Methodological" case studies are generally heavy with data, which have been negotiated with the collaborators and the schools involved. A description including all the data collected in the study is written so as to allow for a first processing of the information and the formulation of an argument. This argument is put together in order to understand the whys and wherefores of the biotechnology topics and the impact derived from its implementation. In the course of this process, and while the data are entering some form of arrangement, they gradually become pieces of evidence illustrating the reality that is being described. The case study then changes substantially: it becomes more succinct and, while certain details which had until then received considerable attention diminish in importance, others, believed to reflect the school's problems most faithfully, take up an important part of the writing. It is this new draft of the study, the result of a new processing of the data, that we shall use in our negotiation with the people involved. The final version, once the stage of negotiation is completed, provides us with an accurate perception of reality. The interpretation and understanding of the phenomenon by participants make up the substantial part of the argument on innovation that we evaluators are putting together at that moment.

The second type of case studies pursues the dissemination of sound practices. But, in order to achieve that end, we need to transform previously written methodological case studies in such a way as to take full account of their contents. In this way, we shall be able to re-write each one of them, this time priorising the description and analysis of innovations and the evaluation of sound practices - practices, in other words, likely to be considered useful and indeed usable by other schools and other (science) teachers. We call these dissemination studies because their specific aim is to stimulate discussion among the audiences concerned with certain topics. This means that they can serve two purposes: dissemination itself and new collection of the data in which we pay heed to the responses of teachers and other trainers concerning the main topics of our case studies. This type of case study must allow others to recognize and even "foresee" what might happen on similar occasions.

THE SPANISH CASE STUDIES

Each of the units has been implemented in upper secondary level by a group of secondary school science teachers. For each of the groups, a specific case study has been carried out, the findings of which are summarised as follows.

Practical Immunology

1. Curriculum and content. Technology in science education.
   - The approach is biochemical/molecular, treated from a reasonably conceptual perspective and underlining immunology as a relatively new topic.
2. The teaching/learning process: the use of the kit as an activity centre.
   - The terms used are excessively "strange" and so impede oral communication among students during the analysis of the most technological part of the experiment and during the experiment itself.
   - The ELISA kit is a molecular-type test, which, according to teachers, creates difficulties in the understanding of the unit. For students, the kit represents an indirect recognition test.
   - The kit is given little value in the sense that it is considered to be "bad laboratory practice"; there is a tendency to identify "what is technical" and "what is technology" as routine processes.
   - The unit is a simple problem-resolving exercise, but the difference between scientific procedure and that of technology is not obvious for teachers, and for this reason, what the problem consists of and how to solve it is not emphasised.
3. Social impact of the use of immunology:
   - No dilemmas arose with ethical problems, although in social impact topics such as AIDS, these types of diagnoses were dealt with.
   - The social impact of fast individual diagnoses is not noticed and, as such, the present and future importance of this technology is not emphasised.

Transgenic Plants

- The unit, always connected with the basic concepts of Genetics, has been used as a way to introduce the concept of Biotechnology and its ethical, economic and social implications.
- The position maintained in the classroom by the teacher with regard to Biotechnology and transgenic plants is of great interest when creating a debate.
- Differences between students from rural and urban environments: The greater closeness of the topic to students from a rural environment seems to be related to a different understanding and focus of the question of transgenic plants and their various implications.
- The use of local and national press articles as elements of connection with student

reality promotes discussion, and thereby leads to the analysis of different views of the problem.

Human Genetics

1. How is the unit placed in the curriculum?

- In all the implementations of the unit, it has been used as a complement to the topics of genetics, and after having previously looked at the topics of genetics and in some cases, the topic of human reproduction.

2. What have teachers emphasised, biotechnology or genetics?

- The scientific concepts related to this unit have been broadly dealt with in almost all cases, especially those related to genetics and more specifically those related to Mendel's hereditary gene factor. There was no difference between the scientific and technological aspects.
- The techniques used for diagnosis or aided reproduction presented comprehension problems, which were seen in the incoherence of some answers.

3. Does the teaching/learning strategy produce informed decisions?

- The curricular topics on genetics are studied and then the role-play is carried out, either as a joint activity or a debate. The debates differed according to classrooms.

4. Dilemmas and/or values.

- The unit creates important ethical aspects or dilemmas among students when making decisions as imaginary parents.
- The idea of having a child "in a natural way" and accepting possible genetic diseases appears with certain frequency.
- Most students had no difficulty in opting for analyses, or genetic or cell therapy solutions, or for abortion, depending on the case.
- When students delve into diagnostic possibilities, and especially into the different treatments, they tend to show overconfidence in technological solutions.

Fermentation

1. Biotechnology on CD-ROM.
    - The biotechnological focus of the unit has prevailed in the implementation of this unit.
    - Participating teachers have taught, for the first time, fermentation from the point of view of biotechnology, which, in terms of teaching-learning strategy, means the possibility of dealing with the topic without the need for any previous complex knowledge.
2. Fermentation in the laboratory: yeast and bread.
    - A supposedly complex and abstract concept of measurement and indirect observation, such as biochemical reactions, are best understood when beginning with

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experiments that are connected with reality.

- Emphasis is placed on the results of fermentation rather than on the process. In other words, the end is to produce energy, and the by-products are what the human being uses.

4. From Fermentation to Biotechnology: the students speak.
   - The comprehension of fermentation as a process which includes microorganisms, and in which there is an energy transformation that produces by-products and waste, which are in turn used by the human being, is clear.
   - In any case, these conceptual errors do not constitute a stumbling block for students when trying to understand what fermentation has to do with biotechnology.
   - There is a general awareness of the complexity of biotechnology, and especially of the step from natural fermentation, or one in the laboratory, to large-scale industrial processes.

EDUCATED DECISIONS AND VALUES

In order to make educated decisions and pronounce judgement on the use that should be made of the applications given to us by scientific and technological knowledge in today's democratic societies, we must be aware of the scientific and technological problems that can or cannot be solved, and who is to benefit from the new technologies, which is something that may not usually be gleaned from the information brought to us by the mass media. In the studies that have been carried out up to the moment, it is apparent that the general public depends on the information offered by the mass media regarding the problems science presents and the level of development it reaches (Eurobarometer 1990, 1993, 1996).

Millar (1996) argued that whilst the knowledge of scientific concepts is necessary, it is not sufficient for evaluating the information given by the mass media. They suggest that it is necessary to: (a) understand the process of the genesis and validation of the tests; (b) understand the evidence science uses and (c) appreciate the inherent uncertainties associated with scientific knowledge. Moreover, the idea is supported that it is necessary to uncover the limitations of science in solving numerous problems, as well as the complications encountered when applying theory to certain practice.

In fact, our argument is that the democratic societies of the beginning of the 21st century need citizens that are capable of taking autonomous decisions instead of having to trust in those made or recommended by the "experts". For this reason, science must be clearly considered as a human construction. We must realise that its theories are provisional, that applying scientific theory in real situations is often the object of uncertainty, and that science does not have a fixed and clear reply to each problem. This is because solving problems is not only a question of research being given sufficient economic resources, but also one of creativity when looking for different solutions.

Many of the biotechnology topics are a way asking students to make decisions which are in line with their values and interests, but it is precisely because the different postures imply contrary values that the sense of responsibility is sought both in the decision that has to be made and in the supporting arguments. More than a few teachers stick to the opinion that students in general have already made their decisions regarding controversial topics, because they are based on principles of either authority or are merely emotional in character. For this very reason, these teachers believe that the capacity for changing values and attitudes towards reality, and towards biotechnology in particular, is very limited. This view is related to the spontaneity and fervour with which secondary school students sometimes vent their feelings, without any rational arguments to back them up. However, one of the purposes of education is precisely to help teenagers formulate complex and critical replies, with reasons that are based on evidence. This first of all requires a process of explanation and explicit formulation of their own ideas. Biotechnology suggests, in many cases for the first time, that students assume the role of an adult who is both conscious of and responsible for the consequences of his or her actions and decisions. This is where the teaching of biotechnology topics fulfils a radical role, in that it forces the student to adopt, orally at least, explicit postures that must be based on reasoning that, in some way, must be coherently reasoned.

Other teachers are of the opinion that education of rational arguments should be a task for the social areas of study, specifically philosophy. Biotechnology, with its educational focus of science, technology and society, breaks that idea by attempting to dynamically relate these three aspects, for it is the socio-historical construction of scientific knowledge and technological applications that is placed on the table at any debate regarding biotechnology topics. The difficulty lies in distinguishing what we call an informed decision and an uninformed decision. The last three years' practice in the implementation of the EIBE units has helped the participating teachers to work out elements that establish this distinction. Some of these elements have been incorporated into the formulation of the questions on the values questionnaire. Basically, there are three aspects which imply a decision should be sufficiently classed as "informed":

- The decision must be based on rational arguments. This means giving a secondary value, without taking away any of their importance, to the arguments of "authority", "faith" and "emotion". At the most, these may form part of the premises of a rational argument, in other words, they may form part of the information that is being considered.
- Such rational arguments must contain at least one piece of pertinent scientific information relative to the topic that is the subject of decision being made. It must back up some of the consequences on which the decision made is based. In other words, scientific arguments must be used, and they must be based on the status of the basic scientific knowledge that exists on the topic.
- Lastly, an informed decision must also be informative with regard to the conse-

quences foreseen in the decision. This point is important in the sense that it indicates that responsibilities are being assumed.

However, it is evident that this approximation to the elements that constitute informed decisions does not answer the question of attitudes as an operative fulfilment of the values that come into play. We find ourselves in educational situations in which teenagers can show significant variations in their personal attitudes. And the imaginary situations in which they are placed require them to assume possible, yet not real, roles. For example, in many decisions, of both individual and social nature, the specific cultural or economic conditions, or the family context, have specific significance which is not shown explicitly in the exercise of making informed decisions. What is carried out in the debates and questions on the questionnaire is fundamentally an educational exercise of reasoning and criticism of present-day techno-scientific topics, and as with all exercises, it has its limits. This is why what is relevant in carrying out exercises on the making of informed decisions is the awareness students express of the need to consider the scientific, technological and social information available so as to solve their own doubts and take up their stances.

AN EXAMPLE: IN THE FACE OF NATURALISM

Perhaps the most significant value that is first shown by 16 to 18 year old students is the one we call "the beginning of what is natural", which may be understood in attitude terms as "what is natural beginning". This value is especially relevant in human reproduction: it implies that students always opt first for what they consider to be the natural process of procreation, in other words, what is based on the sexual relations between man and wife, and on the consequent period of pregnancy and assisted birth. In the field of transgenics, this maximum value is the same as the preference for the products they consider "natural, because they are products that have always been around". With this principle, which is not free from contradiction, what is "natural" is perceived as what is "normal" and "appropriate", whether for reasons stemming from religious authority, or from ecological idealism, which turns nature into a living entity diametrically opposed to the human being and his or her work.

It is interesting to discover that the value of what is "natural" is strongly considered as something relative by students living in country areas, which subordinates this principle to the "pragmatic" one we have previously stated. They are familiar with the fact that agricultural activity "exploits" nature, adapting it to human needs, and so have no problem in supporting, for example, genetically modified products, and are even prepared to dismiss the second term, "precaution". In this case, the economic principle of productivity prevails.

Thus, having understood the possibility of in vitro fertilisation, and consequently, the usefulness of embryo selection in couples who are carriers of recessive genes, and potential transmitters of genetic diseases to their descendants, for example, cystic fibrosis, quite a few students, generally girls, change or modify their initial "naturalist" argument as a result of this new techno-scientific knowledge. After the incorporation of this new biotechnological knowledge, some students, when asked what decision they would make if they wished to have children but were carriers of genes that might transmit a genetic disease, seriously considered all the alternatives involved: pre-natal diagnoses, abortion, have a child that would probably be ill, or opt for in vitro fertilisation to guarantee healthy descendants. Even those students who maintained their "naturalist" argument could see the relative nature of their stance, understanding why a couple in that position might choose embryo selection, even though they personally would not do so.

We believe that this is a good example of how teaching biotechnology by focusing on the activity of making educated decisions can help students to assume, for example, paternity in a responsible way, or to assume the need for gathering scientific or technical information when a decision is to be made. Thus, in the case of transgenic crops, those who argue in favour do so by emphasising, for example, the control of experiments and the numerous tests that minimise any possible harmful effect of these crops. Those who argue against it put forward reasons based on the possible transferral of the resistance to herbicides to other crops or plants, for example. In all cases, the reasons that are based simply on "naturalism" are placed under strict scrutiny when faced with reasons that have scientific or social bases.

Today's society is immersed in a process of reviewing its relationship to techno-science. The progress and development of the techno-sciences, as with biotechnology, imply the active participation of citizens in understanding the risks and advantages involved. This is why the teaching of science fulfils, more and more emphatically, a role of mediator between the "natural" speech of common sense and the "unnatural" speech of scientific investigation. This hinge-like role forces teachers and educational authorities to review – almost constantly – the science curriculum and also, in the last instance, the teaching-learning strategies that are to be implemented in the classroom (S_ez & Carretero, 1999). It is in this new educational role where the need for students to learn to make informed decisions has its place.

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The Forming of Conceptions of the Non-Equilibrium Processes Theory (The General Chemistry Course).

Olga V. Arkhangelskaya, *Arkh@general.chem.msu.ru*,
Nataia A. Zarukina, Igor K. Kudryavtsev, *ikk@struct.chem.msu.ru*,
Igor A. Tyulkov, *Tiulkov@general.chem.msu.ru*,
Chemical Department, MSU, Moscow, Russia

The aim of synergetics is to study self-organization and evolution of complicated nonlinear systems of any nature. This moves it out of any particular science and leads to the qualitatively new level, making possible, in particular, an integration of natural and human sciences. We can regard synergetics as a scientific paradigm of new century [1].

Using the basic principles of synergetics we can model different processes in physics, chemistry, biology, economics, ecology, politics, etc. We can make prognoses and predict different variants of development. In fact, synergetics can be used to forecast and model the future of the whole mankind [2]. This makes it especially important for education which is a basic stone of human evolution. Education based on the principles of synergetics is especially effective since it brings up a person according to the demands of modern age.

We can mark three possible directions of using synergetics in education. The first is synergetics **of** education, the most global and the most difficult direction. That means that the whole process of education must be constructed by the use of main principles of synergetics. The second is synergetics **for** education and means an addition of some special courses on synergetics to the main courses in secondary and the Higher schools. We will not discuss these two directions in this report. Our aim is the third direction, namely, synergetics **in** education. Teaching of some disciplines can not be considered as full and modern without discussion of synergetic aspects of these disciplines. We will consider this problem with regard to the course of general chemistry in the Higher school.

The authors work with the students of biological and medical specializations. The objects of study for these specializations are in principle different from the objects of traditional chemistry which makes an introduction of synergetics in the course of general chemistry for them necessary. We will illustrate this by the use of the three main ideas of synergetics [3]: openness of the system, nonlinearity, dissipativity.

The system is open if it can change substance and energy with the surrounding media. The objects of biology and medicine, i.e. animals, plants, human organism, cells, etc., are open systems. We can give trophic (nutrition) function of circulatory system as an example. It is well-known that blood-vessels and capillaries are connected with all organs and tissues and therefore with all cells of human or animal organism. Blood brings oxygen, sugar, hormones, etc., to the cells and takes away the decayed products which with the aid of excretory organs go to the environment.

The nonlinearity of the system can be illustrated by the autocatalytic reactions which are quite common in the mechanisms of functioning in the living systems. The term "autocatalytic" means that the substance in the chemical reaction catalyzes its own production. This is equivalent to positive feedback that, in contrast to negative feedback, stabilizing system, is the source of growth and instability. The obvious examples are the growth of organism, either in mass or functional, and development of malignant tumour.

Dissipativity is a factor of "natural selection" destroying everything that does not correspond to the main trends of evolution. All chemical reactions not in the thermodynamic equilibrium are dissipative, i.e. producing entropy inside the system. Being far from the thermodynamic equilibrium is one of the main features of the living systems, making possible their evolution. Any living organism is nourished by the highly structured substances with low entropy. As a result it is producing heat and excreting high entropy products of metabolism.

Summarizing we can say that objects of biology and medicine (i.e. living systems) are open systems which have the properties of self-organization and evolution due to their nonlinearity and dissipativity and, therefore, are the typical synergetic systems [4]. Thus, we must introduce the elements of synergetics in the course of general chemistry that is basic for the students of this disciplines [5].

We will discuss now the possible ways of this introduction. The starting point is the 2-nd law of thermodynamics that introduces entropy, breaks the symmetry of time and gives the idea of evolution. The traditional classification of the systems as isolated, closed and open ones must be discussed in details. The possibility of negative entropy flux from the environment into the open systems as a necessary condition for structure formation must be emphasized.

The 2-nd law gives us a possibility to introduce the main concepts of synergetics: system in the state of thermodynamic equilibrium and out of it, dissipation, entropy production in the chemical reaction out of equilibrium, system evolution to some asymptotic state.

The nature of this state can be discussed by the use of methods of chemical kinetics. This methods lead to the differential equations with some initial and boundary conditions. In the beginning we can neglect transport for simplicity and consider only time dependence of concentrations. Now we can see the effect of nonlinearity. If the differential equations are linear we have only one stationary state corresponding to the thermodynamic branch, and self-organization in this case is impossible. But if the equations are nonlinear (the simplest case is the kinetics of autocatalitic reaction), the situation changes and leads us to another important concepts: stability of the stationary state, attractor, bifurcation, control parameters as a measure of distance from thermodynamic equilibrium, limit cycle as a model of steady oscillations. Now evolution can be interpreted as a chain of bifurcations. All concepts must be illustrated by simple kinetic models (Schlogl model, Lotka-Volterra model, brusselator). Belousov-Zhabotinsky reaction gives an example of oscillatory behaviour in the real system. Its model, oregonator, gives a possibility to use realistic values of kinetic constants to model the reaction.

The important for the biologist idea of morphogenesys can be discussed by introducing of space variables and investigating of interplay between chemical reaction and transport. That leads us to the concept of Turing instability – one of the first concept of synergetics, if we consider the chronological order.

The main problem for this kind of activity is to find the simple realistic examples for the mathematically and thermodynamically introduced concepts. This is the main object of our activity in future.

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Constructivism in the Classroom

Nicos Valanides and Charoula Angeli
Department of Educational Sciences, University of Cyprus, Cyprus
nichri@ucy.ac.cy, cangeli@cytanet.com.cy

INTRODUCTION

The challenge in the 1990s for science educators has been to design learning environments in which learners seek, share, and construct knowledge among themselves (Lave & Wenger, 1991; Scardamalia & Bereiter, 1991; Duffy & Cunningham, 1996). Bentley (1996) believes that "currently constructivism is the most popular philosophical foundation for framing curriculum and instruction in science and mathematics, if not in all subjects" (p. 2).

Constructivism, as just mentioned, is an epistemology or a philosophical view of how people come to know. The term "constructivism" has been used as an umbrella term for a wide diversity of views that share the notions that (1) learning is an active process of constructing rather than acquiring knowledge, and (2) instruction is a process of endorsing that construction rather than transmitting information. Drawing from the writings of Kuhn (1970) and Rorty (1991), Duffy and Cunningham (1996) argue that constructivists view learning as an activity in context. Thus, we do not seek "truth" by correspondence to external reality; rather, we inquire workable understandings by actively seeking to interpret multiple perspectives through dialogical discourse (Rorty, 1991). Of course this does not mean that "anything goes," because through social dialectic we test the reasonableness and the feasibility of our views in relation to alternative positions.

As mentioned previously, the term constructivism has come to serve as a general term for a wide variety of views. Amongst the most prominent views are (a) cognitive constructivism, and (b) social constructivism.

Cognitive Constructivism and Social Constructivism

The cognitive and socio-cultural constructivism seem disparate, but they offer some basis for considering "the mutuality between persons acting and the social and cultural circumstance in which they act" (Billett 1996, p. 265) and for building bridges between them. However, they explain the construction of meaning differently.

The premises of cognitive constructivism are derived primarily from the writings of Piaget (1977) and von Glasersfeld (1989). According to this view, learning results from the interaction occurring between an individual's experiences and his or her current conceptions and ideas. Thus, the process of learning depends on the extent to which the individual's conceptions integrate with new information. This integration is characterized as assimilation or accommodation and is guided by the principle of equilibration whereby individuals seek a stable homeostasis between internal conceptions and cognitive conflict from the environment. Thus, "the learning is in the individual's constructions as he or she tries to resolve the conflict" (Duffy & Cunningham, 1996, p. 175). The primary mechanism for cognitive growth is the learner's interactions with the physical environment, while the social interactions and language do not receive primary attention.

The Vygotskian perspective, or the socio-cultural perspective in general, considers the construction of knowledge as a social process where social transactions and discourse are considered to be the basis for any subsequent learning (Vygotsky, 1962). Representations of knowledge are viewed as patterned by social and cultural circumstances. This view "accentuates the social and cultural genesis and appropriation of knowledge" (Billett, 1996, p. 264). Learning is viewed as the appropriation of socially derived forms of knowledge. Appropriation is not restricted to the internalization of externally derived stimuli. It consists of a transformational and reciprocal constructive process (Rogoff, 1995) and results to a co-construction process of cognitive structures (Valsiner, 1994).

Although the relationship between social interactions and cognition is still under examination, we accept the potential contribution of both perspectives to the construction of knowledge, and, in this study, we set out to investigate how a generalized constructivist-teaching model can be used in the classroom to support students' conceptual growth.

A Generalized Constructivist Model for Science Teaching and Learning

The model shown in Figure 1 was used to engage middle school students in discussions and experimentation about shadows, and to examine how social interactions were shaped by the roles students assumed in the classroom as they progressed toward conceptual growth.

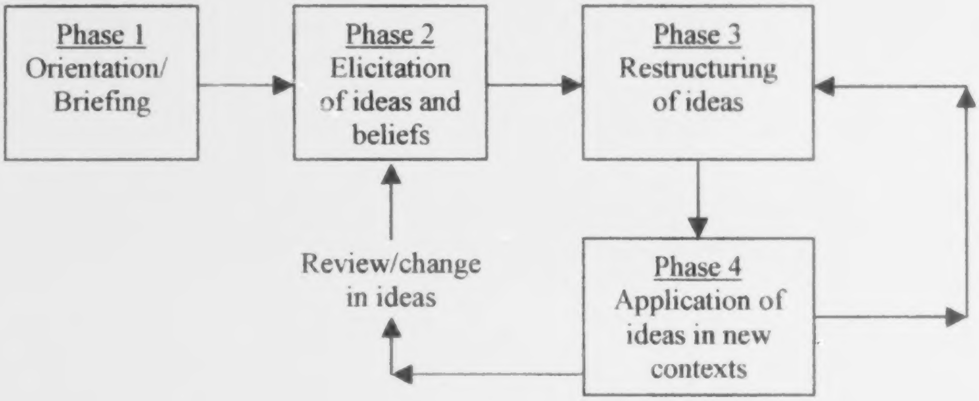

Figure 1. A constructivist model for science teaching (adapted from Scott, 1987)

As shown in Figure 1, initially, the teacher informs the learner about the purpose and the value of the lesson (Phase 1), and thereafter, teaching begins by eliciting students' existing ideas (Phase 2). Eliciting students' ideas at the beginning of a lesson is important because (a) the student becomes aware of his or her current state of understanding and beliefs, and (b) the teacher becomes aware of what the student knows, thus a mismatch between what the student thinks, and what the teacher thinks the student thinks, is avoided (Bell, 1985). The next phase, namely the restructuring phase (Phase

3), is crucially important as students consider the variety of perspectives, which have emerged, and are ássisted in re-examining their initial positions in light of new scientific evidence. Then, in Phase 4, students are asked to apply their restructured ideas in a variety of contexts, both familiar and novel. Moreover, during Phase 4, it is possible that further restructuring will take place. Lastly, students are asked to reflect on how their thinking has evolved since the beginning of the lesson. This constructivist learning sequence, that is from phases 2 to 4, can then be repeated for as many times as it is needed for students to develop conceptual understanding. The next section discusses in detail how the teaching model in Figure 1 was applied in a sixth grade classroom to teach a lesson on shadows.

Implementing Constructivist Teaching in the Classroom

In the present study, the teacher attempted to engage a classroom of 23 sixth-grade students in discussions and investigations in order to construct theories and explanations about shadow phenomena. Discussions and investigations were carefully orchestrated to (a) improve the likelihood that children would recognize the diversity of predictions and explanations about different shadow phenomena adopted by them, and (b) establish consensus about the explanations consistent with canonical science. Particular attention was given to instances in which the children were largely in disagreement during the problem-solving process. All sessions were audio- and video- taped and were later transcribed and analyzed.

Experimental Setting

Before discussing in detail the implementation of the instructional model in the classroom, some reference to the experimental setting is essential. The experimental setting consisted of a rectangular wooden block, which had in the middle of each side an incandescent electric lamp mounted on it. The four lamps were identical and could be turned on and off independently. Moreover, the four lamps were removable and could be replaced with coloured light bulbs. A two-dimensional model of a house, made of opaque cardboard, was also mounted upright at the center of the wooden block. The model showed a house having an inclined roof with a projection imitating a chimney. Three movable pieces of cardboard on the model represented two windows and a door that could remain shut or open.

Orientation/Briefing

Initially, students were involved in discussions related to when and where shadows exist or are formed. This discussion was informal and was carried out in small groups without teacher involvement in an attempt to establish a relaxed classroom environment and encourage student participation. All students agreed that shadows were very familiar to them, and that they could identify different shadows in their classroom. The teacher then explained that they would be discussing about shadows during the session and asked the students to sit in a semi-circle having in the center a big table with the wooden block on it.

Elicitation of Ideas and Beliefs

The teacher initiated the discussion by asking the students to assume that lamp 1 was turned on and to predict what would happen. All students agreed that the shadow of the object (i.e., the two-dimensional model of the house) would appear, and that it would have the shape of the object. However, when the teacher asked them to draw the shadow using a diagram, students' individual drawings exhibited different understandings. The same happened when the teacher asked them to draw diagrams for the hypothetical cases of having each one of the remaining lamps turned on individually.

The findings showed that the disagreements were related to the position, the shape, and the size of the shadow. In general, students predicted that the shape of the shadow was identical or similar to the shape of the house irrespective of the position of the house, but when lamp 3 or lamp 4 was assumed to be turned on, students drew shadows that resembled the shape of the house, but of smaller size than the size of the shadows that students drew when lamp 1 or lamp 2 was assumed to be turned on. Moreover, the drawings of the shadows did not show only the "border" of the house but all the details which appeared on the model including the door, the windows, and the dividing line between the roof and the rest of the house. Some distorted shapes of the shadow of the house also appeared when the teacher asked the students to predict and draw the shadow of the house for the cases when each lamp was in turn turned on and the door and the windows were kept open. For some students, keeping the door or the windows open or closed did not make any difference, but for some others it did. The drawings of those students projected the idea of a three-dimensional drawing, and by looking at the shadow they drew one could even locate the exact position of the movable cardboard pieces representing the door and the windows.

After these initial predictions, the students asked their teacher to provide them with the correct solutions and explanations. The teacher responded that "doing science" means that students have to find a way to work out the correct answers, and he raised questions related to the nature of shadows. The following excerpt is indicative of the discussions that followed and students' conceptions of shadows.

Teacher (T): You drew the shadow here (in front of the house towards the light source). Why? What is the shadow for you?

Student (S1): The shadow is the self of the .. thing.. of the object .. of the house. It is that thing which goes always with them (the things or objects). It never happens to be away from them.

...

T: You told me that shadows are "the selves of the things". How do "the selves of the things" behave? What about our shadows? Do they walk? Do they speak?

All of the students are laughing and the student hesitates to reply, while a student sitting next to her intervenes.

Student (S2): Our shadows do not walk or speak, but we always carry them with us. Wherever we go, our shadows are always there.

T: Do we carry them or do they follow us?

This question triggered opposing points of view in the classroom. Specifically, there were students who favoured the idea of the shadow "accompanying" the objects, as well as students who supported the view that shadows are "carried by" the objects. Furthermore, as indicated by the following statement, there were also students who strongly supported the view that shadows do not exist independently of the existence of light.

> Student (S_3): (Without waiting to be called on). I think that this is not true (referring to the "accompanying" or the "carried by" shadow). In such a case, where is the shadow if we do not have a light source? Can you see the shadow?

This question split the class into two groups quarrelling whether shadows exist independently of the existence of light and thus light only makes them visible, or whether shadows are "caused" or "formed" when light is present.

Restructuring of ideas

After eliciting students' views about shadows, the teacher encouraged the students to use the experimental setting to test their hypotheses. Students listed points of disagreement and with the help of the teacher agreed upon which experiments to perform in order to investigate the different points of view and resolve their disagreements. The previous discussions aroused students' interest and motivation to propose and perform purposeful investigations and get involved in the accompanying discussions. Progressively, these discussions helped the class reach consensus about the position and the shape of shadows. The idea that the shadow belongs to the respective object was, however, so strong that students resisted to change it. Therefore, when they were confronted with a shadow having a different shape than the object (i.e., when lamp 3 or 4 was turned on, the shadow was a line), they insisted on providing different pseudo-explanations, and repeated the respective experiment a number of times as if there was something peculiar about it. They progressively concluded that both the direction and the shape of a shadow are related to the position of the light source, but they did not grasp yet the meaning of a shadow as the absence of light, when blocked by an opaque object.

Application of Ideas in New Contexts

Subsequently, the teacher initiated new discussions about the nature of shadows by asking the students to predict whether a letter written on the surface of the experimental setting could be seen when the shadow appeared toward the letter's position or to predict the properties of the shadow when a coloured light bulb (i.e., green, red, or yellow) was used. These questions prompted new "turmoil" in the classroom. Progressively, students became less reluctant to voice their opinions or to disagree with their classmates' opinions. More students were also complaining that they were not given enough opportunities to participate in the on-going classroom discourse. The teacher, in an attempt to alleviate students' complaints, adopted a voting strategy after the discussion was progressing towards saturation (i.e., there were no longer any new ideas). Specifically, the teacher noted on the blackboard all different perspectives, and students were asked to vote for one of the perspectives. Students were also given the opportunity to provide additional comments, when they felt the need to do so.

Concerning the visibility of a letter when the shadow of the house pointed toward the letter's direction, some students thought that the letter would be invisible, because "it would be covered by the shadow". Another group of students thought that the letter would be visible, less visible, or invisible depending on the "thickness" of the shadow, but they were unable to explain adequately what factors affect the thickness of the shadow. The prevailing idea was that the thickness of the shadow depended on the dimensions (the thickness) of the object. Suddenly, a student who was reflecting on her real life experiences voiced her objection:

(S_3): No .. No, I think that the letter will always be visible. The thickness of the shadow does not affect whether we can see the letter.

(S_4): I do not agree. Think about a … very thick shadow. How can you see something in the shadow?

(S_3): Yes ….you can.... Think about being in a forest … under the shadows of dense planted and …bushy trees. You play games there, you do other things. How can you play or do things if you cannot see?

(S_5): Yes, ... but in such a case you are stepping on the shadow.

(S_3): No ... yes ... but the shadow does not cover the ... the stones ... other things or ... the ground.

These comments prompted new discussions and students started changing their opinions. During the voting process, none of them supported the invisibility of the letter, and most of them voted that "it depends" without being able to provide adequate explanations. When they were asked why they changed their views although they strongly supported them in the preceding discussions, they responded that they were not sure whether the letter would be visible, but that it was safer to vote for the alternative "it depends", because of their uncertainty. Some of the students were more susceptible to adopting their classmates' points of view, and they usually suppressed their own opinions and voted according to the opinions of either their friends or the best students in the classroom. This classroom strategy prevented them from being cognitively engaged in the on-going activities.

During the discussions about the colour of shadows, when coloured light sources were to be used, students expressed ideas that indicated the persistent nature of their conceptions. Thus, the majority of them initially expressed ideas which indicated that they considered shadows to represent the presence of something belonging to the respective object and having material characteristics rather than the absence of light. They supported that the shadow of an object would be red, green, or yellow depending on the colour of the light source, and, in some cases, that the shadow would have a different colour even though they were unable to logically reason about their argument. Some students raised, however, objections insisting that they had never seen coloured shadows. The former group responded that this was true, because in everyday circumstances the light sources are usually colourless. There were, however, indications that the diversity of views concerning the same phenomena induced students to start re-considering and even changing their initial conceptions in the light of the different perspectives, which were manifested during the discussions. Thus, during the voting process, the majority of the students responded that they were not sure whether the shadows would have the same colour as the light source or whether shadows would be dark.

Students continued to struggle for greater participation in the discussions and were complaining because some of them dominated the speaking floor. Students also exhibited more positive attitudes towards experimentation and, early in the discussion, they proposed to resort to the experimental setting to resolve the opposing views manifested during the discussions. They started to respect the different views about the same phenomenon, and they considered the different points of views as an opportunity for experimentation and fruitful interaction with their classmates and the teacher. The experimentation and the accompanying discussions helped them to both consolidate their revised conceptions about the shape and the position of the shadow, and to establish consensus regarding the visibility of a letter covered by a shadow and the colour of a shadow "caused" or "formed" by a coloured light source. Experimentation and discussions induced students to think and reconsider their initial conceptions about coloured shadows. Hence, they started wondering why the shadows did not have the colour of the light and whether shadows are nothing more than absence of light.

Concluding Remarks

Succinctly, the results of this research study indicate that students found learning about shadows with constructivist methods a valuable and enjoyable experience. Specifically, students commented on how they enjoyed the social environment in the classroom and the fact that everybody could have an opinion without worrying that someone might make fun of one's point of view. In addition, they said that they enjoyed the tasks they were given to solve, as well as the social interactions and communication they had with the teacher. Students repeatedly commented on how different this way of learning was in comparison with what they were used to, and kept asking if they could participate in more activities.

Specifically, the findings of the study illustrate that students became, gradually, highly motivated to participate in the learning activities. Their engagement was prolonged as it was reflected by the length of the discussions. Levels of students' engagement progressively rose, and their arguments became more sophisticated. Students were highly tolerant of each other and were willing to suspend final judgement waiting for evidence to be collected through purposeful experimentation. Consequently, they exhibited more positive attitudes toward experimental work, and their motivation for learning as well as their awareness about learning processes seemed to be highly enhanced.

The patterns of achievement, engagement, and motivation were not, however, universal and depended largely on the dynamics of the classroom and students' expectations. The dialogues among students often indicated authoritarian interaction because of the students' different status in the classroom or their different conceptions and motivation. Moreover, discourse in the classroom revealed that students showed resistance in altering their initial conceptions despite of valid and reliable evidence. Conceptual change does not seem to be an all-or-none phenomenon, but a gradual process that depends not only on the learners' past experiences but also on contextual constraints.

It becomes important to intensify research about how specific situations and social dynamics influence the construction of knowledge. We need to better understand how context-situated instructional environments mediate conceptual understanding. Specifically, we need to study how instructional elements promote cognitive development. These elements might include (1) the role of the teacher, (2) the nature of student-teacher dialogues, (3) dialogues between students, (4) how disagreements and different points of view affect the quality of the thinking process and the quality of the product, and (5) the relationship between the problem-solving process and the product.

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STS-Health-Oriented Performance Tasks: Academic Achievement and Attitudes to the Active Inquiry Learning Strategy

Miriam Welicker, Oranim, Academic College of Education
Reuven Lazarowitz, Technion, Israel Institute of Technology, Haifa, Israel
miriamwe@*macam.ac.il* *miriamv@tx.technion.ac.il*

Key Words: STS, Inquiry, Performance Task, Constructivism, Cooperative Learning.

The study goals were to develop STS health-oriented authentic performance tasks and to evaluate the consequences of active inquiry learning through them on students' academic achievements and attitudes, preferences and feelings towards this learning strategy.

The performance tasks are relevant to students' daily life, dealing with risk factors of cardiovascular diseases and are presented in STS (Science-Technology-Society) approach (Yager, 1995; Yager & Tamir, 1993; Bybee, 1987). The active inquiry learning created a multidimensional learning situation, with wide-ranging activities in the sequence of: individual task, cooperative group task (group discussion and experiment), role playing in pairs and groups, class discussion and experiment, cooperative persuasion task and finally a summative individual task. Students had a chance to express multiple intelligences (Gardner, 1993), and to make use of inquiry, psycho-motor and affective skills, brainstorming, consulting, asking questions, raising ideas, weighing judgments, making decisions, critical attitude to their results, drawing conclusions, learning lessons and evaluating implications for the future.

The sample, comprised of 267 tenth grade students, learned the topic "Health aspects of the cardiovascular system" as a prevention program developed by the researchers (two textbooks - 1995a, 1996). It emphasized the awareness of primary prevention of cardiovascular diseases and ways to avoid controllable risk factors - the proverbial ounce of prevention to replace the pound of cure. The sample was divided into two research groups using different strategies to teach "Risk factors of cardiovascular diseases": In the experimental group (N=136) - task-oriented active inquiry learning, based on a booklet of performance tasks (1995b), dealing with cigarette smoking, stress due to competition and to driving on a crowded road, lack of exercise and poor nutrition. Laboratory sessions were held as discussion groups (investigating problems, planning experiments and carrying them out). In class there were frontal and group inquiry discussions, individual tasks, a class task, role playing and drawing conclusions. In the concluding "persuasion project" students' task was to persuade the public to adopt healthy lifestyle for primary prevention of cardiovascular diseases. In the control group (N=131) - "traditional" frontal teaching-learning. In class there were giving-receiving up-to-date information, and in the laboratory experiments were performed to reinforce the classroom learned material.

Three questionnaires (pretests-posttests) evaluated academic achievement (knowledge and literacy regarding cardiovascular diseases, risk factors and primary prevention), attitudes, preferences and feelings regarding the instructional-learning strategy and its contribution to class atmosphere. Teacher training prepared them teach optimally the prevention program by STS (rational, guidance and recommendations) and the student-centered approach. Instruction took place after administering the pretests, following posttests administration. Data were analyzed quantitatively and qualitatively as well. The research results indicate:

a) Academic achievements in the experimental group were higher (ANCOVA: F=23.79 p=.00) with very high effect size (ES=.89). Progress was twice as great, relative to the control group. This advantage points at a meaningful learning of concepts, principles and skills, and greater literacy in health matters linked to cigarette smoking, nutrition, physical activity and stress.

b) The experimental group showed attitudes more supportive of their learning strategy than did the control group (ANCOVA: F=34.90 p=.000), with a very high effect size (ES=1.21). Their net gain was 2.75 times as high as that of the control group.

c) Most students in the experimental group (72-93%) supported their learning strategy, expressed enjoyment, enthusiasm, satisfaction, interest, motivation and personal involvement, preferred to go on studying in this way, investigating for themselves, rather than receive it "chewed" and summed up by a teacher/textbook. 94% reported a sense of ease, comfort and enjoyment, without the "boring lessons" pressure, being encouraged to plan experiments, solve problems and take decisions independently, to bring up their own original ideas, to apply relevant considerations and critical thinking, to confront challenges and to reach a solution of their own for the problem. The constructive atmosphere encouraged growth, cooperation, consideration, mutual help, appreciation of others' achievements and social solidarity. Students in the control group reported a lack of these opportunities. Active inquiry learning was perceived as "impressive, a valuable experience, enjoyable, challenging, encouraging the assumption of responsibility, exchange of opinions and the working out of ideas", helping advance weak students and improve their self-image. Characterizing their group work, 62% reported full involvement and cooperation, while 37% reported partial ones. Both teachers and students maintained that students who generally did not express themselves in class displayed hitherto unrecognized and varied talents in the group work. Thus a window was opened to multidimensional evaluation of students, both by teachers and by their peers.

These results correspond to those of other studies in high achievements attained by students taught in small groups, as compared with those taught frontally (Sharan & Sharan, 1995), and to other studies that examined attitudes and characterized the cooperative learning (Webb, 1995; Cohen, 1994; Baird, Lazarowitz & Hertz-Lazarowitz, 1992). To an amazing degree, attitudes expressed and the picture drawn by the experimental group fits the constructivist theory, by which one may explain the significant difference in achievement between the two research groups (Brooks & Brooks, 1993; Sharan & Sharan, 1995; Vygotzky, 1978; Piaget, 1964). The constructivist theory emphasizes the importance of social interaction and verbalization while brainstorming in cognitive development and in processing information and structuring meanings, by nurturing internal motivation, enjoyment and enthusiasm. The multidimensional learning situation encouraged students to express their competence, multiple intelligences and creativity. Combining active inquiry learning with authentic content, relevant to the student's health and life quality, by STS approach, should help to prepare future citizens, providing them powerful instruments for solving problems and making decisions, rather than absorbing scientific facts passively and memorizing them. In this way, we may advance meaningful learning in heterogeneous classes, scientific and health related literacy along with the informed use of knowledge for improving students' environment, life-style and health, and promoting their personal success in a technological society.

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An MSc Course for Science Teacher Development – An Example of Development Research

Ain Heinaru, Jack Holbrook, and Miia Rannikmae
University of Tartu, Estonia
icase@logos.cy.net

Key words: science education, professional development, teaching, children's learning, research, curriculum and assessment.

In most countries, MSc courses have been conceived as science related academic programmes, heavily geared to additional learning in the subject area. This has tended, in the past, to be the case even when such courses cater for science education, rather than the discipline of science itself. However, the growth of science education research, or its sub-divisions of research in biology education, chemistry education and physics education in many diverse directions in the last two decades has led to a separate discipline in science education. This has created the need for an MSc (or MEd in some countries) course in science education with wider thinking, away from, but building on, the subject knowledge and developing expertise in interrelated science and social science skills. Such courses are needed to build on participants' past experiences in the educational arena, and then attempt to enhance and widen knowledge, thinking and practices over and above that gained from teaching in the classroom, or from earlier efforts in action research.

The Perceived Need

Short in-service professional development courses are common for teachers, but they are not seen nor expected to offer the in- depth extension of skills that major developments in the teaching practices require. With the dramatic changes in science and technology in everyday life and the demand that education reflect these changes in preparing today's youth for tomorrow's world, there is a need to prepare teachers beyond the one-day, or even one-week in-service course. The effectiveness of much in-service provision has been called into question over many years and conferences have been held in this field (e.g. ICASE, 1982). Teachers need to reflect on their practices, to assimilate new ideas and to take ownership of suggested new directions. There is evidence that teachers are not grasping even the basic changes needed in their teaching. Kikkas (2000) found that even though new curricula set up wider goals, teachers still emphasised subject-oriented goals. Even more, teachers did not pay attention to the achievements of the goals. For example, in a lesson where the goals were to teach students to solve problems, a videotape analysis showed that not one problem was given to students to solve. A further issue was that teachers were apt to think better about themselves than they actually were i.e. self-evaluation was high. Kikkas (2000) showed that although teachers think their students were asking a lot of questions, a videotape did not show it; teachers said they planned their lessons against student needs – in fact they followed the textbook; teachers mainly asked lower order questions; teachers did not pay attention to student misunderstandings that arose in the lesson – they did not react to mistaken comments given by students.

It seems taking ownership for students' learning is important if teachers are to adapt their ideas to the situation and be able to appreciate the philosophy, rather than simply the practice. For this, teachers need to be more aware of developments in other areas, the research being undertaken and the journal articles being published. The great advances made in cognitive science research into the various conceptions of constructivism (Fleer, 1999) and how students learn, or appropriate classroom climates (Penick and Bonnstetter, 1993), the STS movement (Yager and Weld, 1999) and now, the recognised importance of promoting scientific and technological literacy for public awareness (Holbrook, 1998), all lead to the need for a greater professional development provision for science educators.

Current Situation in the Filed of Biology, Chemistry, Physics Didactics

The University of Tartu has recognised that a well prepared MSc course can cater for greater professional development. It can be an important professional development provision that enables teachers to have an in-depth look at science education and gain skills that can be helpful to the practicing teacher. Earlier attempts have produced courses in Biology, Chemistry and Physics didactics as shown in the table (Univ. of Tartu, 2000a). The Chemistry and Physics courses contained something like 25- 60% of subject learning and another 25-40% of single subject oriented education specialisation and were thus heavily identified with content. The Biology didactics course recognised the need to concentrate on the subject education discipline and that in recognising Biology education was very different from Biology, there was little need to include studies in the actual science subject. By inclusion of a course in science didactics and nearly 25% free options, the Biology didactics course portrayed a much greater width than those in either Chemistry or Physics didactics.

Number of Credits (total = 40)

Type of Courses	MSc in Chemistry Didactics	MSc in Physics Didactics	MSc in Biology Didactics	MSc in Science Education
Subject oriented	12	15-25	0	3
Subject didactics oriented	16	7-17	19	0
Science education oriented	0	0	4	29
Educational	12	8	8	0
Free options	0	0	9	8

Overall, the didactics courses strongly promoted the separate disciplines, even though there was a growing awareness of the inter-disciplinarity of science and the need to recognise its strong links with technology and technology education.

A New MSc Course in Science Education

The need to develop new courses with wider horizons has been matched by the growing awareness of the importance of the education component in preparing science education specialists (University of Tartu, 2000b). While there was still seen to be room for a science subject component in MSc courses for science education, the emphasis in catering for teachers or others in the education sector, required a course more heavily geared to social science skills and less attention to research methods in the sciences themselves.

The shift in thinking introduced in the new MSc in science education can be clearly noted. Single subject education, seen as a separate entity for teaching practices in each of the separate sciences, is completely removed so that students with a Biology, Chemistry or Physics background can equally study this course. It immediately has the advantage of a far greater pool of potential students from which to draw, but it also emphasises the uniformity from an educational point of view of all the studies being part of science education. Whether students study research methods, information technology, assessment techniques and so on, from a Biology, Chemistry or Physics perspectives is seen as immaterial and the expertise needed is very much related to educational studies.

The science education geared MSc course includes 3 units on new trends in science, designed to introduce new developments currently taking place in the forefront of scientific research. This represents the sole attempt to raise subject knowledge. And by a similar token, no educational theory is included that is not directly linked to a science education framework. Thus courses in general pedagogy, developmental psychology and theory of education are replaced by a philosophical look at science education and teaching approaches in science education.

Science education components are thus the central focus and this dominates the way the courses in the MSc programme are developed. Studies in developments in children's learning and hence the field of misconceptions or alternative frameworks draw heavily on science classroom examples and publications have appeared in this field (Driver, Guesne and Tiberghien,1985; Driver, Leach, Millar and Scott, 1996; Fisher, 1990). These illustrate the importance of teaching that takes note of prior learning and being prepared for student reluctance to accept alternative ideas.

Involvement in research is viewed as another important component to enable science educators to tackle actual problem areas, to delve into the literature and to carry out data gathering procedures before analysing the outcomes. Inevitably this needs to be guided by an introduction to the various research methods, especially those recently coming to the fore in qualitative research (Cohen, Manion and Morrison, 2000). Such research approaches are very different from scientific studies and draw attention to the social science techniques needed for most science education research, where variables cannot be regularly controlled. The important of social techniques means that this MSc course needs to be regarded as a first degree in education and recognised as a new learning direction. It is little wonder therefore that a requirement for initiating studies in this area is a first degree in one of the science disciplines, a teaching qualification, plus 2 years of teaching or related experience in the education field. Added to this, there is the need to give teachers the opportunity to gain more insights into research or action research related to teaching approaches and a need for an awareness of the trends in science education over at least the last 40 to 50 years. And in addressing these trends, it seems appropriate to take a philosophical look at the directions science education has, and is, heading and the influences and constraints that impinge on these (Matthews, 1994; AAAS, 1989).

It would be inappropriate for a course in science education to ignore developments related to 'science for all' (Fensham, 1985), 'relevant science education' (Holbrook, 1998), science-technology-society (Yager, 1996; Solomon and Aikenhead, 1994) and a consideration of the need for scientific and technological literacy for all, or STL (Holbrook and Rannikmae, 1997). A course on the philosophy and teaching approach geared to STL is seen as a crucial component of the programme enabling participants to examine ways to increase the popularity of science in schools and recognise the need to raise public awareness of science. The course provides the basis for a future vision of science teaching and the realisation of the importance of ownership by science teachers in the area of professional development. Research with teachers in this area (Rannikmae, 1998) has illustrated how difficult it is for teachers to overcome the limitations of the curriculum and the academically directed examinations. Yet this is important if teachers are to give serious thought to their teaching and the manner in which teaching can be made more relevant and meaningful to students.

Information technology is playing an increasing role in science education not only for knowledge transfer but also as a means to access ideas and techniques. It can be predicted that visual images in classrooms of the future will be increasingly derived from digital storage or internet sources and multimedia and networking will play an increasing part in science education. An MSc course in science education is seen as substantially enriched by a course on information technology.

Inevitably, such an MSc course would not be complete without a systemic look at curriculum ideas and associated assessment strategies. In countries where the system is centrally controlled, it is usually recognised that teachers are expected to be curriculum implementers, but little attention is paid to considering how this can be made more effective. Furthermore, the teacher as curriculum developer is not seriously entertained, yet adaptation of the curriculum for specific students is seen as important even if this involves re-sequencing of approach, or re-emphasising of the teaching material. Attention to curriculum ideas leads to a course that can give a background in curriculum development, curriculum design and how these intentions can be approached in practice. It is expected that participants on the course can derive a new impetus and be more confident that they have the expertise and direction to assist curriculum development as well as support other teachers in the directions needed. Examining the dominant role assumed by the textbook in many systems can be an area of discussion, focussing on curriculum intentions, rather than those perceived to be the intentions by authors of textbooks. While resources and teacher morale will continue to be problems, especially in developing countries, the course can try to put these into perspective and minimise their impact. It can encourage teachers to try out new ideas, be ready for failure with early attempts to change and to have the confidence to work with others in moving forward, rather than trying to operate in isolation. Assessment of students is seen as a particular problem if attainment is to be the focus and science education is to clearly take on a wider educational direction. A course in this area is seen as important and can reflect on formative assessment procedures, criteria referencing and well as profiling and the incorporation of the assessment of skills associated with experimentation, investigation or project work.

Finally there is the need to prepare teachers for more ownership of the educational process, greater reflection on practices and the ability to carry out research studies. This can involve a readiness to develop materials using the internet, or by simple creations on paper, to discuss issues such as the role of the textbook as well as encouraging participants to seek information for themselves using a variety of resources. The course can lead to a recognition that the goals of education need to be reflected in science education practices and hence 'science for citizenship' is a more appropriate target than 'science for the scientists'. The inclusion of a meaning for scientific and technological literacy and the manner in which it can be operationalised in the classroom setting is crucial. Undertaking an actual research study that is clearly within the science education domain is recognised as a very important element of the programme, so much so that 50% of the total credits are awarded for this and a thesis is required.

The University of Tartu has embarked on such an MSc course. This is a major change and its effectiveness has yet to be judged, although early signs are that teachers find it challenging, more demanding and forcing them to pay more attention to the literature than a traditional MSc course. Also, it appears unlikely that a teacher in Estonia with the usual background embarking on this type of programme can complete the requirements within 2 years and better provision needs to be considered for summer courses and distance learning components.

The target is a science educator who can play a more effective role in curriculum development, guide examinations committees and undertake research in science education in Estonia. The programme is put forward as an important addition to the preparation of science educators and a stepping-stone to a PhD in this field. Inevitably staffing in the University of Tartu may well depends on the success of such a programme.

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Model of Advanced Science Education "Learning Through Research"

Srdjan Verbić, Petnica Science Center, Valjevo, Yugoslavia
Tatjana Damjanović, Faculty of Chemistry, Belgrade, Yugoslavia
verbic@psc.ac.yu tatjanad@chem.bg.ac.yu

PSC is specific educational institution es-tablished in order to enable high school students, highly motivated in science, to practice in scientific research. Material results of their learning are published re-search papers (Reference given. Nevertheless, true goal of that special kind of education is to encourage creativity and to prepare young people for problems that are waiting for them in the endeavor to create scientifically literate society (Bailey 1974).

PSC provides facilities and stimulative surrounding for advanced education and research. All parts of research are prepared and monitored by PSC associates. Their task is to advise and guide students through the research. They are, also, supposed to "catalyze" process of research, because we don't have years at disposal, but only a few weeks. However, research has to be student's deed as much as possible. Otherwise, they miss pleasure, satisfaction for well accomplished job. Important feature of those projects is that they do not require full comprehension of complicated concepts of contemporary science and heavy mathematical apparatus. They demand creativity and teamwork.

Special seminars are organized for those students interested in prob-lems that are out of focus of contemporary science. Some of those problems are neglected because of the way science is funded, the other because sci-ence generally has difficulties to merge methodology and achievements into "pan-scientific" knowledge (Reference given). Participants of those seminars, in spite of their age, do real science. A group of thirty students makes a micro-model of the scientific community.

Unlike the traditionally defined curricula, Learning through Research (LTR) has a program not specified in terms of what is to be taught, but rather in terms how it is to be taught. It is not possible for the school curriculum to keep up with the current growth in knowledge. Perhaps the more important capabilities are to know where to access information and how to analyze it critically and evaluate its quality (Denley 1999). LTR is a model that enables three important moments in the process of knowledge acquiring.

The first one is an opportunity to "discover". A fact or conclusion emerged as a result of exploration becomes unforgettable as well as a pathway. This route is a major source of research joy and excitement, but a way of much more efficient learning also.

The other important moment of LTR is possibility of implementing new science methods in order to confirm well-known fact or principle. Results in students' research surely don't have to be "numbers" seen for the first time. Seeking new methods for establishing the same old fact is research as well. This enables students to be in the front line among professional researchers. New methods are new for all of them. Where is method supposed to be applied, that is the matter of particular problem and the current interests. The third moment is giving young people greater responsibility for their own learning (Bell 1991). LTR model is individually oriented and all students are supposed to realize how important is their own initiative. Our job is to prepare them for individual work. PSC has material and human resources. Students have to develop skill of "navigation" through those resources and learn how to learn.

Although the target group of all PSC seminars are students inclined to research and scientific thought, LTR program strives to avoid role of vocational education. Formally speaking, students included in LTR develop skills required for "scientific capability" rather then "scientific literacy" (SCCC 1996). However, here we have false dichotomy. Both abilities are objectives of LTR. The first one is based on students' personal needs, while the other concerns desired effect on the society.

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A Teacher Training Course in Italy

Luciana Danusso, *ludanuss@libero.it*
V. Mangani, *vimang@libero.it*
M. Vicentini, *matilde.vicentini@roma1.infn.it*
Rome University "La Sapienza", Italy

INTRODUCTION

A post-university specialisation school was set up in Italy during the 1999/2000 academic year for the initial training of secondary school teachers. There has been no specific teacher training in Italy until now, but in the future only people holding a diploma from this school will be allowed to teach. It is a two-year course covering both educational psychology and subject teaching skills. There are also teaching workshops and teaching practice in secondary schools.

This article presents a course, entitled the Curriculum Development Workshop (CDW), aimed at the analysis, design and simulation of teaching activities - which should represent a summary of the know-how in educational psychology and subject teaching from an institutional point of view. The course, which is run by M. Vicentini, has been organised with the collaboration of two secondary school teachers, who are working at the University as training supervisors.

The course programme was only partly defined beforehand (ref. section 2) and it was modified along the way bearing in mind the suggestions of the teachers who guided the training activities for the students and participated in the course as supervisors. This participation enabled the co-ordination of the Workshop and Training activities, but it was only partially co-ordinated with the educational psychology area and with the lecturers of the subject teaching area.

PLANNING BEFOREHAND

The initial course programme (Ref. Table 1) was only prepared for the first lessons. It was presented to the students as a draft of a trial course on a new theme for the lecturer, with the explicit request to work together to prepare a programme which could be subsequently used elsewhere. The aim was not to provide a predefined product, but to favour an active process for construction of individual knowledge in a free learning environment - for adaptation to individual needs. This approach was a continuous test for the lecturer_s attention and sensitivity, with constant feedback and the possibility of modifying the planned route along the way û but within an established organisational network.

In fact, if learning to teach is a complex matter, the CDW may be seen as the appointed place for the processing and the summarising of the know-how which contributes to the professional training of a teacher. The CDW is also thought of û in terms of organisational structure - as the union between theoretical training (educational psychology and subject teaching) and practical application (teaching practice) where the student teacher must also take into account the school environment, the class and the individual students û as will be the case when practising the profession.

It should be noted that the lecturer knew, from previous experience on Teaching Specialisation courses, of the need to guide the students in reflecting on the subject knowledge possessed. This was often lacking in phenomenological and epistemological aspects and in the coherence between the various sectors of the subject (Buontempo 1997). The first planned activities were aimed at provoking exactly such a reflection.

Therefore, whilst the course programme was deliberately undefined in terms of content, it was solidly aimed towards a process of reorganisation of the subject knowledge which occurs either as a result of stimulating situations or from reflections on phenomena of everyday life. Tale arrangement eases the passage to a greater degree of learning of the subject, which is a necessary condition for preparing teaching methods.

It is in fact a necessary premise for a future physics teacher that scientific learning is an integration between a spontaneous process of carefully tested knowledge and formal knowledge, that it is difficult to distinguish the use of the procedure from the use of the necessary content for the organisation of knowledge and that when you pass from one concept to another in the learning process it is not so much the ôexperiencesö which modify our knowledge as much as the ôtheoriesö which are used to give meaning to the experience.

The method of stimulating reflection by the presentation of demo-shows, the discussion of the subjects and the preparation of conceptual maps was continuously used. Subsequently, the student teachers moved on to the group construction of teaching paths. The resulting discussion lead to a reprocessing and rearrangement of the path.

It must be pointed out that, whilst preparing the programme, the lecturer took for granted that the general problems of teaching/learning and curriculum design would have been priority subjects in the teaching modules of the educational psychology area. This would therefore have allowed even greater attention to be given to aspects specifically of a subject nature for the development of curriculum units for physics.

From the very start it was decided that the learning evaluation would have been carried out on the basis of a final report regarding the presentation of a proposed teaching method and the students were notified accordingly. Subsequently, the preparation of a "portfolioö (Silvermann 1996) was suggested, containing a presentation of the notes taken during the lessons, with personal thoughts and comments on the lessons.

ACTUAL DEVELOPMENT OF THE COURSE

The programme is illustrated in Table 2 and some comments are given below:

a) the interest aroused by the 1st ôdemonstrativeö trial lead to the request for other trials of the same type. Nevertheless, there is the impression (from the final evaluation) that the majority of the participants have grasped more the aspect regarding the use of low-cost equipment than that of the encouragement to reflect on the knowledge possessed and interactive teaching;

b) the suggestion to set out the preparation of the final report on the physics hidden in technological objects was received with interest by the majority of participants The request to evaluate the course programme was also received with interest and attention. An intermediate report (which was not evaluated) was also prepared by many of the participants containing comments, ideas and suggestions.

c) A positive experience of effective co-ordination.

The idea arose during an open meeting between some university lecturers and the teachers. The teacher in charge of the teaching communication module accepted to evaluate the communicative abilities of the course lecturer during a meeting with both parties. The subject lecturer provided the other lecturer with the notes on the meetings which had already been held in order to start planning the joint meeting. The two lecturers exchanged some e-mail messages and the planned agreement was easily reached. Even the teaching communication lecturer, as well as the participants, was stimulated by the ôdemonstrativeö trials and organised the intervention on the understandings highlighted during the trials themselves. The intervention of the psychologist stimulated further thoughts by the subject teacher on the communicative possibilities of the trials. A second meeting was therefore planned in order to carry out another trial in which the psychologist would have participated and on which he would have subsequently commented. It was observed that the majority of the students received the message and some aspects were inserted in the final reports.

This co-ordination trial highlights:

- the use of the portfolio prepared by the lecturer as a means of communication with other lecturers,
- the importance of an empathetic-type human relationship between the lecturers who wish to co-ordinate their interventions;
- the importance, in that relationship, of a deep respect for the reciprocal technical and teaching duties,

and obviously:

- the importance of programmes with explicit points in which to efficiently insert the co-ordination;
- the willingness of each lecturer to be placed, respectively, in the position of learning by the intervention of the other lecturer.

Is it possible to acquire professionalism which favours co-ordination? It is not easy to answer this question at the moment.

d) Co-ordination with the training activities. The participation of the supervisors has enabled the proposal, during the assisted training activities, of activities linked to proposals made during the lessons and for the lecturer to take into account some problems which arose during the training. Some assisted training meetings have therefore been dedicated to the construction of work sheets for teachers and students, regarding the ôdemonstrativeö presented during the lesson. This proposal was found interesting since the students were able to understand how the work method was to be implemented by means of the form and not merely an operational method and, therefore, also the non-sterile nature of the workshop instructions.

MODIFICATIONS ALONG THE WAY AND REVISION OF PROGRAMME

Some of the modifications which were made along the way have already been mentioned. It is worthwhile taking note of the modifications in order to justify the modification of the programme for a future revision of the course:

I. introduction of the theme of self-teaching and of the portfolio as an evaluation document. This subject must be brought forward as an introduction to the course along with other modules which also highlight the transferability to teaching situations in Secondary Schools. In particular, in order to achieve satisfactory learning it is necessary to encourage the use of personal reflection (on the basis of notes or memories) on information received during lessons or teaching meetings, by processing final notes near to the dates of the lessons themselves.

II. Co-ordination with modules in the educational psychology area. Experience has shown the usefulness/need of this co-ordination. It is necessary, however, to set it up during the initial planning and to take care that it is distributed between the lecturers of the respective programmes.

Course evaluation. An overall evaluation of the teaching effectiveness of the course may be made by analysing the final reports of the students and the course evaluation forms for all the subject modules.

It is seen from the students_ reports that:

- not all the students have been able to include the subjects dealt with in the course in the teaching activity proposals;
- the majority of students have integrated well the educational psychology professor_s lecture on understanding;
- the teaching role of the ôdemonstrativeö trials has not been fully understood;
- there is a widespread tendency to set up the teaching units on the basis of general (or generic?) declarations on "objectives" and "prerequisites" without correlating the objectives with the results of the learning and the prerequisites with that which the students should know at the beginning. Only a few, in particular, consider the problem of evaluating the actual possession of these prerequisites.

- the types of evaluations proposed in the units generally take the form of multiple-choice questionnaires.

The students were asked to fill in an evaluation form at the end of the course and the findings were on the whole positive.

There has been a very explicit request by some to receive, from the course, instructions in the form of a ôrecipeö. The lecture on the use of teaching proposals should, therefore, also be brought forward to discourage the use in the profession of teachers who are not willing to actively manage the teaching activities themselves. A possible strategy for the students should be studied to divert their expectations to receive ôrecipesö towards the understanding of teaching as an active process, by means of which "the correct recipe" for that situation is found every time. This expectation may in fact be justified in the schemes of spontaneous teaching (Vicentini, 1991) prepared by the students during all the school years (especially the years at university) in which they are asked to follow lecturer_s instructions provided by means of a traditional teaching. These schemes may actually have produced a conceptual conflict (unresolved) for a course with highly interactive teaching

CONCLUSIONS

The scheme used this year appears to be a valid proposal for the Workshop Courses according to the legal requirements. Nevertheless, it is important to underline the need to satisfy some boundary conditions:

- better co-ordination with the teaching activities carried out in the other courses. As well as the awareness of the programmes before the courses, it would be useful, with this aim in mind, to have notes of a portfolio type prepared by the students;
- a more explicit encouragement, in all the courses, for the active participation of the students by means of interactive teaching methods;
- a better arrangement of the students' evaluation tests (examinations).

TABLE I

Planning in advance[1]

Lecture No.	Subject
1	Teaching as a form of information communication. The development components of a curriculum
2	Teaching strategies for teaching Physics
3	Curriculum analysis
4	Co-ordination and integration between various teaching activities
5	Exercises in the construction of teaching proposals
6	Exercises in the construction of teaching proposals

[1] Each lecture was composed of two hours of theoretical work and three hours of group work.

TABLE 2	SUBJECTS
1st lecture	**Development components of a curriculum with the focus on teaching Presentation of a teaching model taken from Communication Science with highlighting of possible communication gaps. Specific problems for teaching physics starting from a reflection on the subject knowledge. Homework: reflect on the mechanics indicating important subjects.**
2nd lecture	**Discussion on the mechanics based on the homework. Introduction of conceptual maps as a teaching instrument and group preparation of the map of the mechanics. "Demonstrative" test on the dropping of cans, filled to different degrees, along a curved rail. Relative discussion.**
3rd lecture	**"Demonstrative" test on dissolving of ice cubes on conducting or insulting medium. Discussion of the thermodynamic processes and concepts related to the test. Analysis of the technologies used in the kitchen.**
4th lecture	**Group work on the operation of "technological objects". Bibliographical research for elements useful for the explanation of these operations.**
5th lecture	**Discussion of homework regarding commonly used technological objects. Presentation of constructive learning model and illustration of spontaneous physics schemes. Discussion of SSIS access tests.**
6th lecture	**Illustration of the evaluation problems starting from the forms prepared for the evaluation of the SSIS teaching activities. Joint activities with a lecturer of the educational psychology area with the re-reading, from a psychological/communicative point of view, of the "demonstrative" trials previously presented.**
7th lecture	**Discussion of the problems emerging from the reports presented by the teachers/students Discussion of: the concept of heat with regard to the processes, temperature and thermometers, the working of the Moka, the particle model in the explanation of technology.**
8th lecture	**Joint meeting with the professor of the educational psychology area regarding the presentation and analysis of the "demonstrative" trial on coloured shadows.**
9th lecture	**Illustration of teaching methods and strategies. Group work on scientific explanation starting from the solution of the problem "friction and demons" (Rogers, 1960).**
10th lecture	**Discussion of evaluation problems. Illustration of portfolio. Illustration of an analysis grid for a teaching exercise.**
11th lecture	**Teaching method and intelligence. Discussion of useful knowledge for the teaching profession. Illustration of report on SSIS access tests.**
12th lecture	**Illustration of useful knowledge for the profession. Prerequisites behind the questionnaire for orientation towards the Physics Degree Course. New discussion on ingenious physics.**
13th lecture	**Presentation of some of the work of the participants with clarification on the subject aspects, on teaching and epistemological methods and on the characteristics of the "demonstrative" trials.**

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Pilot Study of the Conceptions about Science of Pupils from the III - IV Grade

Liliana Ciascai, Vasile Chis, and Adina Maria Pop
"Babes - Bolyai" University, Cluj - Napoca, Romania
lchicinas@personal.ro

Luminita Chicinas,
County School Inspectorate of Cluj, Cluj - Napoca, Romania
luminita@isjcj.ubbcluj.ro

"Why to change the school curriculum if not in order to develop competences, skills and knowledge of the pupils, competences and skills more specific, more opperational and more useful during long life and in their career?" (Philippe Perrenoud, 2000).

An educational reform, started since 1997, focused on the following main problems:

i. systemic changes in the school management

⇒ new approach of school' management (school as educational services provider accordingly to the community needs and interests)

⇒ schools' inspection (as support for improving school performance and development)

⇒ the education quality (quality indicators and criteria built in order to improve school ethos and results)

ii. facilitating professional development

⇒ in-service training for teachers, head-teachers and inspectors

iii. new curricular approach which ensure the pupil centered teaching and learning

⇒ five curricular areas: *Language and communication* (Matern and Modern languages), *Mathematics and Sciences* (Mathematics, Physics, Chemistry, Biology), *Man and Society* (History, Philosophy, Psychology, Economics, Religion, Civics), *Arts and Technologies* (Sports, Painting, Music, Technological Education) and Counseling

iv. new approach of pupil and schools assessment and evaluation

⇒ new design of K-8 and K-12 national examinations

⇒ new structure of academic year (2 evaluation period of time, each during 3 weeks at the end of each semester).

One of the main areas of the educational reform consists of a new curriculum for all grades and consequently new syllabuses, new textbooks and other curricular supports for better teaching - learning activities in classrooms. We now ask "why to change the textbooks if not for...". Because, both the syllabuses and new alternative textbooks seems to ignore an essential fact, namely, the pupils came to schools having already knowledge and personal way of thinking very different to that of scientific experts. The pupils have already a system of conceptions which is ignored by the syllabuses' authors, as well as by the teachers teaching that subjects.

In this paper we proposed to identify some of the pupils' conceptions referring to the scientific content of sciences subject studied by the III - IV grade pupils and to design a strategy in order to overcame these conceptions.

First, we document the main conceptions mentioned in the pedagogical literature for the pupils in the grade III - IV (9 - 11 years old). Secondly, we select conceptions from three main interests domains known by the pupils in these grades: human body (respiration, digestion), biology (cell, plants growing, seeds, germination), astronomy and physics (planet movement, cosmic space and vacuum, gravitational attraction, electric current, heat - temperature relationship, light). Finally, we start to investigate the presence of these conceptions at the pupils (9 - 11 years old) by means of techniques and procedures described in literature (reference given).

The most used techniques were: images or schemata of knowledge about a concept, fact, phenomenon realized by pupils; comments on the basis of a schemata or photography; stating or explaining with their own words of a fact, idea; stating a prediction concerning a fact, phenomenon. From the conceptions identified by the above techniques we chosen four of them concerning: respiration, gravitational attraction, electric current and light. For each of those conceptions we designed overcoming strategies following the models from: "Representations' overcoming by activating the socio-cognitive conflict" and, "Representations' overcoming by finding out the limits", respectively (J.P. Astolfy, M. Develay, 1989, p.82 - 83).

The didactic approach applied in order to overcome these conceptions started from the following assumptions:

(i) using only a few fundamental notions and concepts expressed in simplest terms possible and

(ii) avoiding to use a lot of new scientific concepts and notions. The pupils participated at activities organized individually, peers or groups.

Systematically, the proposed activities were:

√ to evoke anterior knowledge: as answers to the question: "what did I know about ..." and statement of predictions as answers to the questions: " what I would like to know about ...";

√ to analyze and solve a problem or qualitative problem;

√ to research the problem in order to solve it;

√ to confront their products (ideas, partial or final solutions);

√ to confront the solutions obtained with anterior knowledge as well as with their predictions and expectations;

√ to formulate final written conclusions.

Each case study finished with an analysis made by each pupil of the initial conception and with an inventory of inexactitudes. This analysis represents the testing phase of our study. After three - four weeks we accomplished the re-testing which consists in a new investigation about the presence of a given conception, using one of the techniques mentioned above. The results are also presented and interpreted in our paper. We notice that the target group consists of pupils from III and IV grade

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Images of animals: Conversations of primary school groups at Three-dimensional, Life-sized 'Representations' of Animals - zoo, museum and robotic animals

Sue Dale Tunnicliffe

Homerton College, Cambridge, UK

sue@sdtunnicliffe.demon.co.uk

Zoos and natural history musuems diplay only 3_D images of aniamls albeit varied in nature. In this study these images are provided by (a) robotic models in a museum; (b) preserved animals in a museum c) animals in a zoo, in constructed exhibits.

Do people have to see the 'real thing' in order to learn about animals, and, if not what do they mean by 'real'? In a zoo, a viewer does indeed see a "real animal", albeit one that usually exists in an artificial setting without any prey, predators or other natural threats. Hence the zoo animal is yet another type of image, live but represented in a human constructed frame and constrained by this very design. The design of an exhibit sets a context in which the animal is seen and this artificially created surround helps form the image of the animal in the mind of the onlooker. There are several alternatives to live animals as exhibits. Those commonly used are museum or taxidermically preserved animals and models of animals made from glass fibre or other materials. Such replica models can be static or animatronic (robotic) models which move to a certain preplanned degree. These three dimensional representations of animals may be life sized, magnified or reduced in size. The models attempt to illustrate firstly the salient anatomical features of the living animal and secondly models of animals also seek to portray certain characteristic behaviour through either, for static models, the positions in which the animals are exhibited together with relevant associated artefacts and biofacts which illustrate the natural environment within the exhibit. Dioramas are the peak of such static exhibits. It is only more recently that certain museums have begun to provide robotic animals in their exhibits. Such exhibits can be popular with children but they differ in several crucial respects from living specimens (Tunnicliffe, 1996). In particular, robotics move in a predictable and stereotypic fashion.

One way of exploring the effacy of the differnt types of animal image is to analsye the content of conversations of children and their accompanyign adults when they are faced with several different types of representations.

The data at the live animals and at the preserved animals were collected between 1992 and 1994 at London Zoo and the Natural History Museum London. The robotics data were collected between 1993 and 1997 at two separate dinosaur exhibits in the Natural History Museum in London, UK. Apart from the dinosaur robotics, the majority of the preserved animals which the groups viewed in the museum were traditional, taxidermically preserved animal exhibits within a glass exhibition case.

Unsolicited conversations heard in the museum and zoo were audio tape-recorded, transcribed and then analysed. In all, approximately 35 hours of children's conversations were tape-recorded and transcribed. This resulted in a total of 1288 units of conversation, 422 of them at the robotics and 407 of them at the conventional preserved specimens and 459 at zoo animals.

A unit of conversation was defined as beginning when a group started talking at an exhibit and concluding when they stop talking. These units provide the raw data of this study.

First, all the transcribed conversations were read through to get a feel for the sense of the dialogues. Then, repeated listening allowed each comment within a unit of conversation to be coded into one or more categories. This coding into categories was done according to a systemic network. A total of 74 categories were used to construct the systemic network. The full network is provided in Tunnicliffe (1995) . Within each unit of conversation, each category is only recorded once, however often comments fall into it. Various other descriptive demographic data such as the types of animal observed and the type of adult accompanying the group were also recorded.

Systemic networks are hierarchical and the four major categories of the systemic network used here were:

- Management and social comments;Exhibit-focused comments; Exhibit access comments ; .Animal-focused comments which were about the animals.

  Animal-focused comments were allocated to one of six subordinate groups viz. Interpretative comments, Affective comments ; Environmental comments which referred to a natural habitat or endangered status of a species; Body parts comments which are comments about an animal's structure;Comments about the animals' behaviours which included the position of the animal in its enclosure and any attention attractor behaviour which attracted the attention of the visitor, such as mating or fighting; Comments about the animals' names.

The contents of the conversations that were generated at the Natural History Museum by primary school groups at the two different types of animal show that there are both interesting similarities and interesting differences between the conversations.

In terms of similarities, it is clear, for a start, that virtually all the conversations (97% at the preserved animals and 95% at the robotic models) include interpretative comments. In addition, most conversations (61% at the preserved animals and 73% at the robotic models) include comments on the specimens' anatomy . Equally, most conversations (66% at the preserved animals and 72% at the robotic models) included management / social category comments. There were also some very marked differences between conversations at the preserved animals and the robotics. Preserved animals generated far more naming comments (85% versus 42%) while, as might be expected, the robotics generated many more comments about behaviour (66% versus 37%) and about whether the animals were real/alive (38% versus 15%).The results may be indicative or an attitude amongst schools that the zoo is predominately an experience of a social nature with some observations of animals. The very focused nature of the dinosaur exhibits may direct the attention of the groups to the particular aspects of the exhibits that the designers considered salient, the visitors receive the message and discuss it, whereas in the zoo the explicit and inherent messages of the exhibits are largely unreceived.

Moreover, the setting in which the animal image is exhibited also contributes to the image which the children construct from their visit. The museum experience is, in that sense, impersonal and optional. Robotics tell a clear, but short, story to which children typically attend closely. In the zoo, the animals in their constructed surrounds are available for viewing if the visitor so chooses.

All kinds of three-dimensional representation discussed here – preserved animals in museums live animal in the zoo and robotic models in museums– provide the learner with opportunities to see anatomical features more fully than is the case with two-dimensional representations whether moving (as in films) or stationary (as in books). The museums images provide a far better opportunity than do the live animals because their position can be guaranteed and any exhibit artefact which draw the attention of the visitor to salient features are certain to be repent. Whereas the live animal may not even be visible to viewers when they reach the exhibit. Such opportunities give a teacher the chance to discuss these anatomical features and introduce those which are used by zoologists in categorisation. Similarly, three-dimensional representations, especially robotics and carefully positioned preserved specimens, provide clues about characteristic behaviours which the children may pick up or the teacher can extend.

Well designed and constructed 3-D robotic models replicate a short period in time of the life of the animal(s) portrayed. However, robotic exhibits differ in several crucial respects from those of museum animals which do not move. Robotics move, but unlike live animals, they do so in a predictable, repetitive fashion but their movements can enhance the message the exhibitors want to convey, unlike the unpredictable messages given by real, live animals.

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What is Alive? How do Arabic-Speaking Israelis Conceptualize Living and Non-Living?

Bar, V., Zinn, B., and Abdo, B.
Hebrew University of Jerusalem, Jerussalem, 91904
miram@cc.huji.ac.il

It is known that both children and adults attribute life to non-living objects and also have the opposite tendency of judging living things as non-living. Both animism and inanimism result from the inability to discriminate between living and non-living, but this does not adequately characterize the richness of ideas emerging in a non-western setting. In the context of Arabic-speaking Israelis, linguistic factors as well as cultural beliefs play a role in the understanding of 'life', 'living' and 'non-living.' Two tasks were administered to probe participants' ideas. Task 1 in which they had to choose the odd item from a group of three and justify their choice. Task 2 explicitly elicited participants' judgment of living and non-living. Questionnaire and interview data showed similarities and differences of Arabic-speakers views to those reported about Hebrew-speakers in the research literature. The subjects were 5th, 6th and 10th graders, special education pupils, adults, among them teachers, kindergarten teachers and science teachers. The inclusion of teachers enabled following typical teachers' misconceptions and their transmission to pupils. This study is carried out with an ethnically and geographically distinct region, with a wide range of ages and populations represented.

Results showed sixteen variants of the accepted scientific view in which only living creatures are identified as being alive. The scientific concept is at variance with intuitions supported by culture and language. Difficulties with plants as living among 10-11 year old are similar to results with Hebrew-speakers of the same age. These difficulties may arise from the effect of linguistically similar Arabic and Hebrew languages on concept acquisition. Animistic notions about "fire" and "cloud" may be traced to associations with 'holy fire' and 'holy water' in Christian rites.

Twelfth-grade Students' Understanding of Velocity: Horizontal Motion under Gravity

Nicos Valanides, and Myrto Poungare
Department of Educational Sciences, University of Cyprus
Nichri@ucy.ac.cy, chpoungare@dial.cylink.com.cy

Introduction

Everyone deserves to share the excitement and personal fulfilment that can come from understanding and learning about the natural world. Everyone deserves to be able to employ scientific knowledge in making intellectual choices and taking decisions that arise in everyday life. For this, people need to be able to learn, think, reason, evaluate, make decisions, and solve problems. The aim to "prepare future citizens" is related to teaching science to elementary, secondary, and even university students in this direction. It is however well known that a high percentage of students often pass their science courses without meaningful understanding of the subject matter. High school and college students often complete their physics courses without understanding how physics concepts relate to the real world. A science-and-technology literate person is one who uses science concepts, process skills, and values in making every day decisions as he or she interacts with other people and the environment, and understands the interrelations between science, technology, and other facets of society, including social and economic development (NSTA, 1971, pp.47-48). The objective of preparing future citizens who are literate in science does seem, however, not to be realised.

Over the last few decades, international research on students' conceptions resulted in a vast literature that catalogued students' interpretations (Boeha, 1990) or attempted to explain the origins of these interpretations (Bliss & Ogborn, 1994). The terms alternative frameworks (Terry & Jones, 1986), alternative conceptions (Ramadas et al., 1996), students prior conceptions (Driver, 1988), misconceptions (Hestenes, 1992), preconceptions (Arons, 1990), and conceptual profiles (Mortimer, 1995) have been used to refer to students' understandings that are at odds with the well-defined meaning of science concepts held by the scientific community.

Students, due to their everyday life experiences, have pre-conceptions about science terms such as force, motion, and velocity. These pre-conceptions need to be restructured to reach comprehensive knowledge of scientific concepts. Research has shown that many of the pre-conceptions students have, are remarkably similar to pre-Newtonian physical theory popular in the 14th through 16th centuries.

In everyday life, most of the movements people or objects make, are composite ones. The way students understand and conceptualise these movements is of particular importance. A lot of research done in mechanics involved the movements of objects and their relation with the forces acting upon them. Besides, the topic of mechanics constitutes an important area in science teaching, because most of the concepts involved in it are found in many other parts of science. The topic of mechanics also defines the main tools in physics and presents the most universal laws in the universe.

The present study examined twelfth -grade students' understanding about velocity when objects move horizontally under gravity. The students followed the science section of the upper secondary school in Cyprus. In this section, science (physics, chemistry, and biology) and mathematics constitute the major subjects of study. Students attending this section have in general higher abilities than students attending the other sections of study do. In terms of prerequisite knowledge, the students, who participated in this research, studied mechanics and movement of projectiles in eleventh grade. The findings of the study will be of particular interest for teacher pre- or in-service education, curriculum development, and teaching or learning science in general.

Methodology

A questionnaire with six problems was administered to a whole class of 30 students (18 boys and 12 girls). Each problem consisted of a diagram representing the motion of an object from an everyday life situation. The diagram was accompanied by a short verbal description of it, and students were asked to make a qualitative prediction about the motion of the object. Students were not expected to obtain and report numerical or extended answers, rather they were expected to show, as clearly as possible, their understanding of the situations presented in the questions and their reasoning. Since this work is still in progress, for the purpose of the present study, we will only discuss preliminary findings in regards to two of the six problems participants solved. Problems 1 and 2 are explained graphically in Figures 1 and 2.

In the first problem, the diagram showed a man holding a small ball as he was running along a horizontal path. At a certain point, the man released the ball, which moved subsequently independedly of the man. Students were asked to show the path of the ball from the moment it was released until the moment it reached the ground and describe in writing their reasoning (Figure 1).

The second problem was part of McCloskey's study (1983) and showed an aeroplane dropping a parcel to the ground, as it was moving horizontally (Figure 2). Students were again asked to make a qualitative prediction about the motion of the ball from the moment it was released until the moment it reached the ground, and to show the path in the diagram. This problem was similar to the first one both in terms of difficulty and in terms of the concepts involved in adequately answering the accompanied questions. The context of the problem was somehow different from that of the first problem. This was a deliberate choice that provided a means of checking the consistency of students' answers.

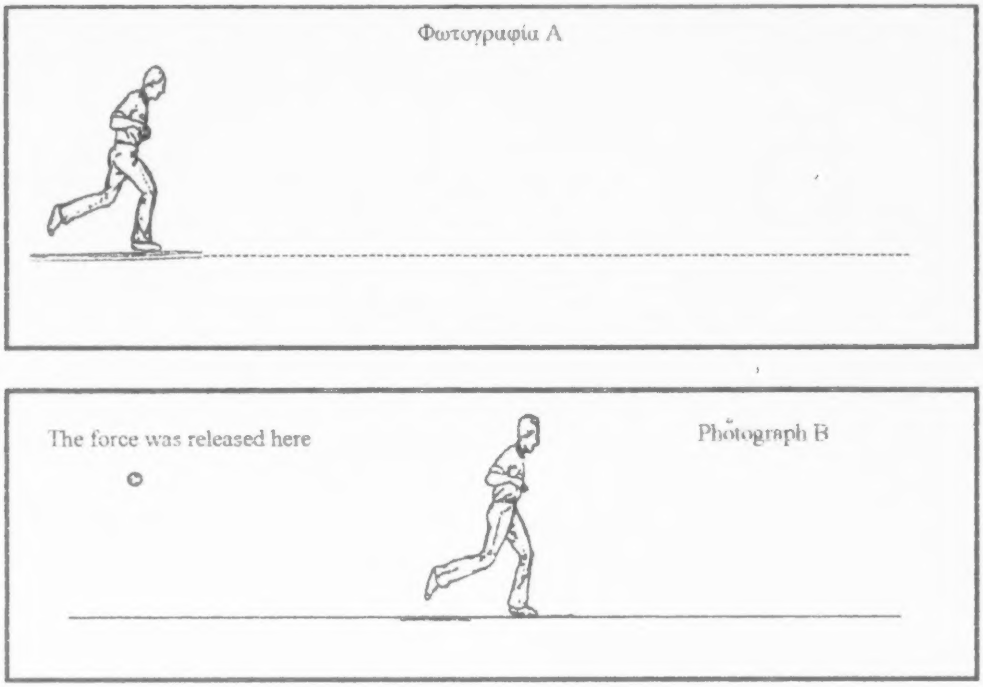
Φωτογραφία A
The force was released here
Photograph B

Figure 1

Direction of movement of
the airplane
Climbers

Figure 2

Eight students were subsequently selected and were individually interviewed in an attempt to clarify their answers to the two problems. During the interviews, special equipment was used in order to examine in depth students' understanding about velocity during horizontal motion under gravity.

The special equipment was a dynamics trolley with an electronic mechanism attached to it (Figure 3). When a switch was turned on, a steel ball was attracted at the top of the hanger due to an electromagnetic force. Just below the ball, an empty cylindrical receptacle was attached. A sound sensor on the mechanism was used to release the ball as soon as someone would clap his or her hands. The function of the sound sensor was demonstrated to the students, when the trolley was motionless (stationary) and students observed the ball falling into the receptacle. Students were then asked to predict what would happen when the trolley was in steady linear motion, and someone clapped his or her hands again. Obviously, the motion of the ball resembles the motion in the two written problems described earlier. Each interview session lasted 20 to 30 minutes and it was audiotaped and later transcribed verbatim for further analysis.

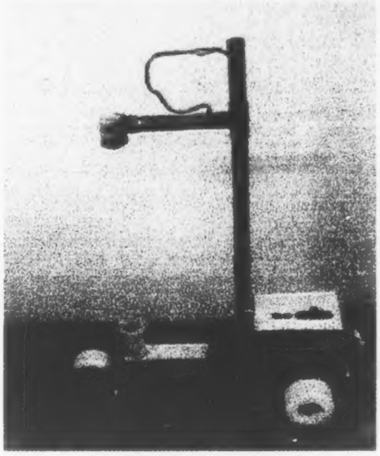

Figure 3

Results and discussion

Preliminary analysis of the questionnaire and analysis of the interviews showed clearly that twelfth-grade students attending the science section of the upper secondary school in Cyprus continued to hold alternative conceptions about velocity and horizontal motion under gravity gravity, even after formal instruction. Their alternative conceptions were similar to those identified by previous research (Clement1982; McCloskey, 1983; Driver, 1984; Osborne, 1980,1985; Hewson, 1985). Thus, the results showed that the majority of the students believed that:

(i) wherever an object is moving, a force is necessarily acting upon it in the direction of the movement,

(ii) a moving object acquires an internal force that keeps the object moving (impetus theory),

(iii) when an object moves with constant velocity, then a constant force is acting upon it, and

(iv) the speed of a moving object is proportional to the force causing the motion.

Table 1 shows a summary of the results from the one-to-one interviews with eight students selected from the total class, after they completed the questionnaire with the eight problems related to mechanics.

Table 1

Students' conceptions about the motion of the ball
After being released from the dynamics trolley

Students' conceptions	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
The ball after being released has the same horizontal velocity as the dynamic trolley	√	√	√	√		√		√
Gravity is the only force acting on the ball after being released	√	√	√	√		√	√	
Gravity and force from the dynamics trolley act on the ball after being released					√			√
The ball will move vertically downwards							√	
The ball will follow a parabolic path covering a shorter horizontal distance than the dynamics trolley				√	√	√		√
The ball will follow a parabolic path and reach the same horizontal distance as that of the dynamics trolley	√	√	√					

The results in Table 1 indicate that students' conceptions were not totally consistent. For example, only three students understood that the ball, after being released, will continue to move horizontally with the same velocity, and that gravity will act on it causing it to follow a parabolic path. These students clearly stated that the ball will cover the same horizontal distance as the dynamics trolley, and that it will fall into the attached receptacle. One student (S7) thought that the ball will have the same velocity after being released, but he expressed the idea that the ball will move vertically downwards. Three other students (S4, S6, and S8) insisted that the ball would follow a parabolic path covering less horizontal distance than that of the dynamics trolley. Interestingly enough, one of them (S8) considered that the ball, after being released, will acquire a horizontal force towards the direction of movement, but, contrary to this, he insisted that the horizontal distance covered by the ball will be shorter. Another student (S5) expressed the idea that a horizontal force in the direction of the motion, beyond gravity, acts on the ball after being released. The student insisted, however, that the ball will not have a horizontal velocity and that it will cover a shorter horizontal distance than the dynamics trolley, because of air resistance that will affect only the motion of the ball. He also claimed that gravity would reduce the horizontal distance covered by the object by virtue of being bigger than the "transmitted" horizontal force, which "dissipates" and comes finally to zero. The following extract from the discussion of the interviewer (I) with one student (S5) shows clearly his way of thinking.

I: What were the forces acting on the ball after it had been released?
S_5: Gravity and the contact force between the ball and the hanger.
I: What is the direction of the contact force?
S_5: Horizontal. The ball will move both horizontally and vertically.
I: So when the ball is released, what will be its path?
S_5: It will be parabolic.
I: Can you be more specific? Can you relate the distance travelled by the ball and the one by the trolley?
S_5: Due to air resistance the ball will cover less distance.

I: Assume there is no air resistance, then what will happen?
S_4: The same as before since the force of gravity is bigger than the other force so it will go down sooner.
I: What happens to the other force?
S_4: It eventually decreases to zero since the ball is not in contact with the trolley any more.

Student's last answer reminded us of the "impetus" theory in which the act of setting an object in motion imparts to the object an internal force or impetus. Impetus functions to maintain the motion and gradually dissipates as a result of external influences. Some of these ideas were also expressed during the discussions that we had with the students concerning the two problems in the questionnaire. Table 2 presents a comparison of students' inconsistent conceptions in relation to the two problems that were discussed during the interviews.

Table 2

Students' conceptions about the motion of the object*
After being released from a moving entity**

	S_1		S_2		S_3		S_4		S_5		S_6		S_7		S_8	
Problems	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Students' Conceptions																
The object after being released has the same horizontal velocity as the releasing entity	√	√	√	√	√	√	√	√			√	√	√	√	√	√
Gravity is the only force acting on the object after being released	√	√	√	√	√	√		√			√	√	√	√		
Gravity and force from the releasing entity act on the object after being released							√		√	√					√	√
The object will move vertically downwards													√	√		
The ball will follow a parabolic path, covering less horizontal distance than that of the releasing entity	√				√		√		√		√	√			√	√
The object will follow a parabolic path and reach the same horizontal distance as that of the releasing entity	√		√	√		√		√		√						

* The object was a ball for problem 1 and a parcel for problem 2.

** The releasing entity was a man for problem 1 and an aeroplane for problem 2.

Some interesting conclusions may be drawn when comparing the results in Tables 1 and 2. Due to space limitations, only some general characteristics of students' responses will be presented here. First, the results in Table 2 indicate that students exhibited inconsistent ideas when discussing the movement of the objects (ball and parcel) for the two problems in the study. Clearly, not all of them were able to relate the two problems and realise that they presented the same motion in different contexts. Students gave more correct answers for the second problem, both during the interview and when answering the questionnaire. For example, a smaller number of students considered the motion of the ball in the first problem as a composite one consisting of a horizontal motion with a constant velocity and a vertically accelerated motion due to gravity. Thus, in problem 1, six students suggested that the ball would execute a projectile motion covering a shorter horizontal distance than the man would. On the other hand, in problem 2, only two students had the same idea for the released parcel. Similarly, only one student in problem 1, but five students in problem 2, found the correct answer. The different ideas expressed by the students for the motion of the objects of the two problems might be attributable to the fact that problem 2 is a common problem that teachers use in class, while this is not true for problem 1.

Some students expressed the idea that since the man was initially holding the ball he was exerting a force on the ball that continued to act on it even after it had been released. This was not, always true for the different conditions of the second problem (the moving aeroplane releasing a parcel). Fewer students found the correct path for the object in problem 1 and more for the object in problem 2. When the aeroplane problem was presented to 48 students in the research of Green, McCloskey, and Caramazza, (1980), 19 subjects drew forward arcs that looked more or less parabolic. Fifteen of them indicated that the plane would be directly over the ball when it hit the ground and another four indicated that the moment the ball would hit the ground, the aeroplane would be well ahead of it horizontally. The most prevalent idea was, however, students' belief that in a vertical projectile, two forces, gravity and an "acquired" horizontal force, were acting on the moving body, ignoring air resistance. Indications of students' alternative ideas can be found in the following discussion of the interviewer (I) with a student (S4):

I: What are the forces acting on the parcel in problem 2, after it had been released from the aeroplane?

S_4: Only gravity is acting on the parcel.

I: And where do you think the aeroplane will be, when the parcel will hit the ground?

S_4: Just above the parcel.

I: Now what do you think about the object in problem 1? What are the forces acting on the ball after the man released it?

S_4: Two forces are acting, gravity and the force given by the man.

I: What do you mean by " the force given by the man"?

S_4: This is the force when the ball was in contact with the hand.

I: If so, what happens to that force after the ball is no longer in contact with the hand?

S_4: It's given to the ball and stays since the ball moves for a while horizontally.

I: Do you see any resemblance between problem 1 and 2?

S_4: There is some, but the ball will hit the ground sooner than the parcel.

I: What do you mean?

S_4: The ball will not move longer than the man will, and it will hit the ground sooner than the parcel.

Conclusions

As this study showed, students failed to transfer school knowledge about the notions of velocity and trajectories in new contexts. The results of this study are indicative of the fact that traditional didactic approaches to instruction, with their focus on transmitting canned knowledge to learners, are for the most part ineffective in making learning meaningful. Current trends in science education advocate active learning for students in order to make science relevant to everyday life. Thus, a paradigm shift in science classroom teaching based on constructivist teaching methods is essential for changing the way students learn and teachers teach. The implications for teacher education are significant since preservice as well as inservice teachers need to be trained appropriately for using constructivist methods in their teaching.

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Resources Supporting Teaching, Including Locally Produced Equipment, Visualization Ideas Using New Technologies

Which (and How) Science and Technology Education for Future Citizens?

George Kalkanis, University of Athens, Greece
gkalkan@cc.uoa.gr

INTRODUCTION

In order to answer these questions we must, first, answer a pre-question: which is going to be the era of the future from scientific and technological point of view?

From the scientific point of view we prospect a unified consideration of the universe, according to the unification models / theories, which describe our cosmos –although in a relativistic / probabilistic way– as structured by a unique ά-τομον particle, interacting with a unique force and ruled by a few and simple principles: from microkosmos to macrokosmos.

From the technological point of view we expect some more advanced applications of the contemporary scientific –physical, chemical, biological,...– models, based mainly on the microscopic structures and processes and operating on the basis of probabilistic and statistical methods.

From the educational point of view –which is related to our first questions–, we propose:

- a change to the science curricula, shifting the content of "modern" physics, transforming the time sequence and instruction models / methods of teaching quantum mechanics (in early upper secondary education), as well as reconstructing the teaching sequence (in lower secondary and primary education) from microkosmos to macrokosmos –and not vise versa–, a change which may promote the unified / cohesive character of science (physics, chemistry, biology,...) and the probabilistic way of thinking.
- a reform of the content of technology education, enhancing it with nowadays state of the art technological tools and processes, which are used in all aspects of everyday life and in everyday human activity and need (scientific, economic, medical,...), whilst presenting them as the direct application of the contemporary scientific models.
- by the use of information technologies, monitored by the computer, as an indispensable educational tool –both "in situ" and "from distance" education–, simulating / visualizing / animating the operation of the physical processes and their technological applications (both from microscopic and macroscopic point of view), whilst feeding / reacting the computer from/with the physical parameters through sensors / actuators.

The trend of science to foster a unified –although realistic / probabilistic– and continuously updated model, as well as the need of education to follow this trend, are reflected in some resent proposals [1,2,3,4], which promote the transformation of the content, the philosophy, the sequence and the instruction models of science curricula. Concerning the content, the curricula of physics courses (in upper secondary and university education) should be incorporated into a generalized scheme, which relates the established knowledge during the last two centuries: Classical Physics (Newtonian Physics, Electromagnetism, Thermodynamics) and NeoClassical Physics (Quantum Physics, Relativity, AstroPhysics), with the new frontiers of Physics: Modern Physics (Quantum Cosmology, Quantum Informatics, Complex Systems, Thermodynamics of primordial / quark matter). Concerning the philosophy of those curricula, what is needed is a break out of the disciplinary framework and a new presentation of science, shifting from a mechanistic to a realistic / probabilistic view of our kosmos –and, then, vice versa–and promoting the plurality / interdisciplinarity of knowledge, which produces paradigms for understanding nature in all its many aspects. The unifying elements could be the few universal principles / constants (in upper educational levels) and the structure, interactions and processes of microkosmos (in all educational levels). Concerning the sequence of the curricula subjects, it is proposed to have quantum mechanics integrated throughout the first physics courses (in upper secondary and university level) rather than just tacked on at the end – if taught at all. Concerning, finally, the instruction model, it is proposed an, even, qualitative approach of the basic ideas of the quantum mechanics, which accessed at the very early stage of science education might lead students to form a unified image of microscopic and macroscopic phenomena, compatible with the scientific one, and to convince them that the real world / kosmos, structured from microcosmos to macrocosmos, is not as relentlessly deterministic as they might expect from newtonian mechanics.

The need of reformation of the content of "technology" taught in school is, also, following the continuous and rapid widening of the range of the technological resources –tools or/and processes– by some edge technologies, which are the products of the nowadays scientific models. The nowadays technology curricula are usually dominated by traditional "old fashion" technologies, still appearing a remarkable hysterisis between the current technology and technology education. The enrichment, as well, of the technology curricula with all those state of the art, "modern" technological applications could serve not only as the necessary updating elements for all educational systems, but also, as a trigger for the student's interest in studying science. Furthermore, the study of the related scientific models and their technological applications are proposed to be combined with hands-on activities (computer visualization or/and experimentation), [3,4].

The proposed changes to the science and technology education curricula could be gradually supported by some critical –from educational point of view– applications of information technologies: computer simulation / visualization / animation of many bodies realistic systems, dominated by stochastic processes and described by probabilistic modeling (like those of microkosmos), whilst the computer is interfacing with the real kosmos through sensors or/and actuators [5,6,7]. The stochastic and probabilistic character of the real system's processes, as well as of the operation of many nowadays edge technologies, require for their modeling the use of statistical methods, by means of random numbers obeying specific probability distributions. This kind of modeling, long well known and widely used by researchers, may also be used for educational stimulation and animation (or visualization through animation) by the computer, since the –nowadays and in the future– schools and educational institutions can be equipped with powerful enough computers. On the other hand, the use of simulation / visualization and computer interfacing (in situ in the laboratory or/and from distance through internet) eliminates the need for expensive laboratory equipments / prototypes, and familiarize the students with the means of automation and robotics. These two applications (preferably interacting) could ameliorate –even legitimize– the use of information technologies in science and technology education.

THE CONTENT OF SCIENCE AND TECHNOLOGY EDUCATION

The proposed reforms in the content of science education may be codified by the sequences "from modern to neoclassical to classical physics" and "from microkosmos to macrokosmos – from a relativistic / probabilistic to the mechanistic / almost certain view of our kosmos". Consequently, the proposed reforms in the content of technology education may be codified by the sequence "from the traditional to contemporary edge technologies".

From Modern to neoClassical to Classical Physics

The evolution of Physics during the 20th century has created new fronts in the scientific research by transforming the contents of the modern physics in a rather established "neoclassical" scientific knowledge, and by shifting the agenda of modern physics to new challenging problems concerning, for example: the universal symmetries of nature, the space-time structure, the meaning of "information" as a quantity belonging to the physical world or the primary laws of the universe. The new trend in natural sciences is, on the one hand, to define the fundamental laws regulating the behaviour of matter in all scales (from microkosmos to macrokosmos) and in all the phases of evolution of the expanding universe and, on the other, to link the fundamental principles of quantum physics with the properties of living matter. This evolution imposes epistemological and educational reforms.

From the *epistemological point* of view, quantum theory and theory of relativity unquestionably established as scientific paradigms according to Kuhn [8], imposing a new schema which bounds the open fronts of physics (modern physics) from the established scientific knowledge gained during the last three centuries. According to this schema three categories are distinguished with different epistemological character: the established (and generally accepted), the almost established (and scarcely disputed) and the open (and generally investigated). The three categories include, respectively:

- Classical Physics: a) Classical (Newtonian and Analytical) Mechanics (Lagrange, Hamilton, Liouville equations), b) Electromagnetic theory, c) Thermodynamics and Classical Statistics.
- NeoClassical Physics: a) Special and General theory of relativity, b) Quantum Physics, Relativistic Quantum mechanics (Dirac Equation), Quantum electrodynamics, Standard model, c) Astrophysics (Expanding Universe, Stars evolution, Cosmic background radiation,...).
- Modern Physics:
  a) Quantum Cosmology: In recent years, the progress of quantum field theories for the description of the interaction between the elementary particles gave the opportunity to form a picture for the evolution of the universe, accepted almost totally, so that it is mentioned as the standard model of the Universe. This brought out the problem of the unification of the quantum theory with the general theory of relativity, that is the creation of a quantum theory of gravity [9,10]. Gravity is the only one of the interactions that influences the causality, one that has deep consequences in the question of the black holes and the loss of information [11]. The existence of the "dark" matter and energy plays critical role in the cosmology and defines the critical density, which determines whether the universe is closed, open or flat. Recently, experimental data speak for the opinion that the universe is flat and has been subjected to an inflationary expansion [12].

  b) Thermodynamics of the primitive matter: If the evolution of the early universe was a process of phase transitions connected with the successive uncoupling of the interactions, it can be studied in the frame of quantum statistics. The creation of the quark-gluon plasma equivalent to the ions and electrons plasma of the electrodynamics managed recently in experiments of collision of superrelativistic heavy ions in CERN [13] opens new horizons in the understanding of the properties of nuclear matter in extreme thermodynamic conditions (of density and temperature), equivalent to those believed that prevailed in the first stages of the evolution of the universe (one hundredth millisecond after the big bang) [14].

  c) Quantum information: The introduction of information as a physical concept begun by Boltzman, who connected the increase of entropy (foreseen by the second thermodynamic law) to the loss of information when a system is described with macroscopic variables [15]. The quantum theory of information is applied in the quantum teleportation and in the future construction of quantum computers that operate with quantum superposition of the dual digits 0 and 1 and show significant advantages compared with the compatible computers [16].

  d) Complicated systems or Thermodynamics of evolution: The initial observation is that complexity is not restricted in biology, but invades in physics and seems to be rooted in the laws of the nature (e.g. liquid crystallization, turbulent flow etc.).

A pressing need emerges for the revision of the reduction principle, that is the reduction of the whole in its parts. In contrast, elements concerning the world in its total enter into the expression of the fundamental laws of nature. The correlation of great range between the various parts of the system create a functional structure and lead to the complexity [17]. The evolution towards complexity results from the irreversibility and the removal from the thermodynamic balance that leads to a not linearity in macroscopic scale in combination to the existence of instability.

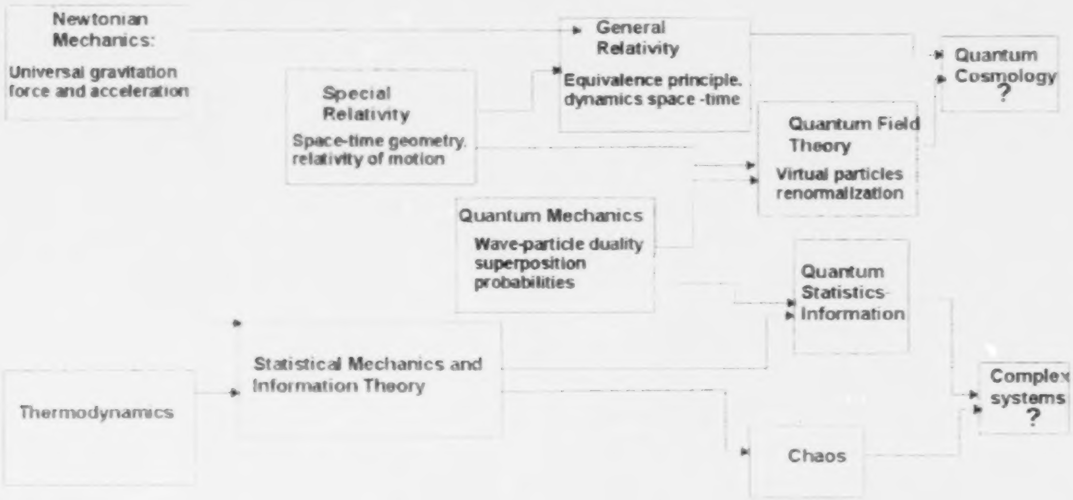
e) The role of the universal constants: The unifying elements in this hierarchy of phenomena consist of terms like energy or information and a group of universal constants, like the Planck constant h, the speed of light c, the gravity constant G and the Boltzman constant K. The first two are the characteristic constants of the fundamental theories of the neoclassical physics that is relativity and quantum mechanics respectively. The constants G and c of Relativity enter into the description of the universe, while h and K are interpreted as quanta of action and information and enter into the description of the microscopic structure of matter [18]. The simultaneous introduction of the constants unifies the theories, while according to the principle of equivalence, the nullification or infinitation of the constants leads to the included approximating theories. So, from the general theory of relativity that constitutes a relativistic theory for gravity, as G→0 is taken the special relativity, while as c→∞ the newtonian theory for gravity.

From the *educational point* of view, is there an influence of the evolution in the fronts of the scientific research or the epistemological contemplation of physics in the content, but also the way of teaching physics, in the beginning of the 21st century?

The teaching of Physics in the upper secondary or the university level should be adapted to the new trends of science, by adopting the new ideas in a methodical way through the creation of an appropriate curriculum, which is based on the scheme of the epistemological classification that was previously set out. At the same time, of course, a crucial problem that should be resolved is how to transfer the basic terms of physics and the new developments from the research centres to the university amphitheatres and from the universities to the school classes.

Aiming at those adaptions, there should be put forward an appropriate connection between the ideas from various categories of epistemological classification, in order to result in a unified scientific frame that could constitute the reference model of a cohesive educational approach [1]. When teaching a new group of phenomena, even in the frame of classical physics, at the same time (in different levels of strictness) there should be introduced terms that are inherent in the "neoclassical physics" or arise from the new reality which is revealed through the discoveries of the modern research that takes place in that specific field.

For instance, in an introductory lesson of Newtonian mechanics it should be mentioned that the mass, which is introduced in the second Newton's law of motion, does


Newtonian Mechanics:
Universal gravitation force and acceleration
Special Relativity
Space-time geometry, relativity of motion
General Relativity
Equivalence principle, dynamics space -time
Quantum Cosmology
?
Quantum Field Theory
Virtual particles renormalization
Quantum Mechanics
Wave-particle duality superposition probabilities
Quantum Statistics-Information
Statistical Mechanics and Information Theory
Thermodynamics
Chaos
Complex systems
?

not remain unchanged or that the Euclid's Geometry is also expressed through physical laws. The passing from Maxwell's Electromagnetic Theory to the Special Theory of Relativity, in the principle of equivalence and Quantum Mechanics, should be expressed as a combination process with reference to the limits of applicability of each theory.

It appears as a challenge to introduce quarks and gluons as the structural elements of the matter –instead of protons and neutrons–, in an introductory lesson of nuclear physics in upper secondary level of education. Of course, this view is strengthened by the recent discovery of the new condition of matter (quark matter). We believe that it is easier for the young students or undergraduates to understand first how quarks interact through the exchange of gluons and then to build simplified models for the interaction of protons-neutrons. In a relevant way, during the established study of the movement of free electrons in metals or photons emission from atoms in an introductory lesson of nuclear physics in upper secondary level of education, it is possible to communicate terms like superconductivity or terms from laser physics.

But during the discussion of questions of classical or some of the neoclassical physics notice should also be given special in some concepts which have fundamental function in the structure of physics in general or influence drastically the research of modern physics. As such, we could mention the principles of symmetry and their relation to the conservation laws [19] found in the basis of the contemporary theories of unified description of interactions [20]; or the definition of entropy in terms of the number of the micro-situations corresponding to a given macro-situation, a fact that relates entropy with the physical concept of information; the wave-particle duality and the interpretation of the wave-function; the uncertainty principle, which, apart from the fact that it stamps quantum mechanics and has caused intense disputes of philosophical kind, it is possible to be utilized for the introduction of very important conclusions in a simple way, like, for instance, for determining the energy of the fundamental state of the hydrogen atom or the relation of energies released in a chemical or a nuclear reaction.

The sense of organization scale of matter and finally the role of the universal constants in relation to the principle of equivalence, where it can be mentioned for instance that geometric optics results from wave physics in the limit where the wavelength tends to 0 and the classical mechanics results from quantum physics in the limit where the Planck constant tends to zero.

With the previous approach it is expected that the scientific consideration of a unified universe could also be an educational consideration. In the frame of this perspective, the fundamental terms of "classical mechanics" and "neoclassical" physics will be the unifying element of this hierarchy, also preparing the introduction of "modern physics" in the future. The combination of scientific models and unifying elements in this scale could fulfil the scientific reformations and the perspectives of science education in the future.

From microKosmos to macroKosmos –
– From a Relativistic / Probabilistic to the Mechanistic / Almost Certain View of our Kosmos

The science curricula still reflect, in general, the traditional division of science in a few separate disciplines, each based theoretically on a few macroscopic models of classical physics, usually presented in a phenomenological and formalistic way. On the other hand, the microscopic procedures, which create and rule the macroscopic phenomena, are usually taught segmentally and supplementally only in the upper levels of education, following the sequence "from macrokosmos to microkosmos", whilst quantum mechanics is usually tacked on at the end of science courses – if taught at all. This approach, apart from leading to an superficial study and the loss of the hidden underneath procedure, reduces instruction and learning to a memorization of some factual knowledge and excludes the procedural one.

An instruction / learning sequence, as proposed, "from microkosmos to macrokosmos" applied already from the early stage of secondary education –or even from primary education–, may reveal a much more unified scientific framework, which describes a rather simple origin of the complex reality and allow students to construct a procedural than a factual view / knowledge about the various phenomena of kosmos. The natural occurring structures, studied in various branches of science, are the products of the same microscopic elements of matter, interacting with the same forces and obeying to the same principles. The unified view of our kosmos may brake out the disciplinary framework, using the common microscopic processes as unifying elements, and may promote the cohesive character of science (physics, chemistry, biology,…).

Of course, this science education approach is still presenting the worldview of classical physics. By focusing on "classical" microkosmos (playing with billiard-ball atoms / molecules, string-like bounds, well defined paths,…, as they are proposed by classical mechanics, gravitation, electro-magnetism,…) we may extract a wonderful lot of explanations of almost all macroscopic phenomena, represented in terms of the interactions and motions in microscopic scale. However, these causal mechanisms, restricted to classical models only, seem so obvious that the outcome of every action could be predicted – that is, said to be "determined" in advance. Moreover, some of these models seem so straightforward that they could be broken down mentally into their constituents and then reassembled to perform just as before. This "reducibility" is really only tenable in physics and chemistry, but it is elevated into a metaphysical principle, supposedly applicable to science.

Throughout the nineteenth century, researchers were exploring the whole natural world, from volcanic eruptions to human psychology, and disclosing a wonderful variety of entities and phenomena that could not be made to fit into these schemes. But science education is so firmly concentrated in a few disconnected, localized areas of knowledge, each supposedly covered by an established discipline, that these other features of the real world are scarcely considered to be "scientific". The science curricula still foster a "mechanistic" worldview, characterised by naive reductionism and predictive determinism, even though these properties belong only to a few highly simplified models representing selected aspects of reality.

The incorporation, as proposed, to the science curriculum the neoclassical models of relativity and quantum mechanics, even qualitatively, in the early stage of upper secondary education, may be an effective answer to the apparent epistemological and educational / instructional problem. This early attack might prevent serious misconceptions and help students to develop a new way of thinking about our kosmos; a new worldview. Moreover, it might lead students to form a more complete realistic and unified updated image of microscopic and macroscopic phenomena, compatible with the scientific one, and enable students / future citizens, who are not willing to attend specialized science training, to reach the core ideas of their days theories, mainly those that introduced radical modifications into human thought (scientific, philosophical, sociological,...) as well as the contemporary technological applications. This updated knowledge is a basic right of all citizens, referred as such to most national constitutions (!).

Of course, an educational strategy aiming at an even qualitative approach to neoclassical schemes in early science education needs a stable epistemological and educational foundation, having the potential to overcome the difficulties of the whole task. This strategy has to overcome first the difficulties of science teachers and secondary the difficulties of the students. Science teachers have the same misconceptions, which appear to be (see [4] and others) the result of their late pre-/in-university traditional instruction. Learners' having just a tacked on of relativity and quantum mechanics at the very late secondary and university education, appear to build a conceptual framework consisting of an overlapping or mixing-up of the conceptual frameworks of classical and neoclassical physics.

This conceptual framework imposes a –long before established and still dominated– deterministic worldview, stemming from newtonian physics, which provokes a classical approach in any effort of learners to understand quantum mechanical processes opposing to their empirical beliefs. This "metaphor" and all relevant misconceptions form *epistemological obstacles* to the acquisition of knowledge.

To overcome these obstacles, an *instructional model* is proposed. Its main goal is a radical reconstruction of learners' initial knowledge, which is characterized by the mixing-up of two paradigm concepts: classical and neoclassical quantum physics. It is founded on the assumption that the juxtaposition of the two representative theoretical models of the two competitive paradigms might provoke a "crisis" situation, similar with the historical one and capable of revealing the deep conceptual difference between classical and quantum physics.

The model is based on some widely accepted assumptions of cognitive science, concerning the learning process: (a) learners have already formed some strongly held mental-cognitive structures from sensory perception and widely spread social beliefs, (b) the instructional process should lead learners to build their new "scientific-cognitive structures" by means of a total radical or weak reconstruction of their initial knowledge (if it is inadequate or sufficient to deal with new scientific content, respectively) and (c) the learning process focuses on primary concepts, in the context of a concrete scientific theory, thus parts might be understood in the context of wholes, not as isolated facts.

The model is also based on some epistemological-pedagogical assumptions that constitutes the accepted epistemological framework and the entire educational perception: (a) the educational process should communicate the contemporary "unified scientific paradigm" that includes the scientific content (that is, the body of knowledge accepted by the contemporary scientific theories) and the scientific inquiry (that is, the methods and practices / activities that lead to the acquisition and development of scientific knowledge), (b) the scientific content, which is intended to replace the learners' initial cognitive structures and forms the "target-structure" of the instruction, should be as accurate as possible, and (c) the scientific inquiry, which should "build" the scientific content, has to promote the understanding of the values / assumptions of scientific knowledge, as well as to provide the processes by which that knowledge was created and developed historically.

The "target" scientific content, accepted by the model, is proposed to be structured in distinct levels, "levels of reality", which classify physical phenomena. According to this classification, the newtonian physics and quantum physics are referred as two distinct levels or as two totally independent conceptual systems. The proposed scientific inquiry, however, should relate these conceptual systems in such a way as to make apparent the unified character of our kosmos accepted by contemporary science. The main assumptions of this approach may be in brief as: (a) each level includes some covering laws (i.e. Newton's laws in classical physics level, Heisenberg Uncertainty Principle and Schrödinger Equation in quantum physics level) and some secondary laws which particularize the covering laws and associate them with concrete aspects of reality (i.e. inverse square gravitational law which form the theoretical model of the planetary system in classical physics; electrons orbitals form the theoretical model of the probability spacing in atoms), (b) the theory(-ies) / models of each level form a particular ontological status, thus a radical reconstruction should be attempted to provoke an ontological shift (from the "newtonian objects" to "quantum objects": discrete states are replaced by superposition principle, predictability is replaced by partial unpredictability of the physical world, distinguishability is replaced by indistinguishability of identical physical objects,...), (c) each level form a totally independent conceptual system, thus a radial reconstruction should lead learners to the recognition of totally different explanatory frameworks and thinking pathways, without any mixing up (classical analogies are not allowed for the interpretation of microscopic phenomena, as usually it happens in the case of the view of atoms as planetary systems).

The model has been applied, tested and evaluated with the support of an *instructional tool* [22] in the form of a computer simulation / visualization environment representing the hydrogen atom's orbitals, which was selected as the key topic of the instructional model.

From Traditional to Contemporary Edge Technologies

A reform of the content of technology education is also proposed, enriching it with nowadays state of the art technological materials, tools, techniques and processes, which are used in all aspects of everyday life and in every human activity and need (scientific, economic, medical, ...). These should be connected with the relevant contemporary scientific model and should be presented as the direct application of those scientific models.

The enrichment of the technology curricula with all those state of the art, "modern" technological applications could serve not only as the necessary updating elements for all educational systems, but also, as a trigger for the student's interest in studying science. The study of the related scientific models and their technological applications are usually proposed to be combined with hands-on activities (experimentation or/and computer visualization) [3,4].

Concerning the experimentation, the trend is to use low-cost hands-on experiment. The feasibility of such experiments, published and tested so far, proves the feasibility of the proposition. Concerning computer visualization, if it is highly interactive –as recommended–, it may be concerned as hands-on activities as well. Students must think and manipulate interactively, as it is proposed in the following paragraph that refers to the information technologies in science and technology education.

THE INFORMATION TECHNOLOGIES IN SCIENCE AND TECHNOLOGY EDUCATION

Science and technology education may be gradually supported –nowadays and in the future– by contemporary information technologies, in all their many general applications: presentation of information / knowledge in all possible modes (text, images, animation, sound,...), instructional software used in situ or/and from distance (through internet), etc. Two special applications, however, may be proved indispensable for science and technology education in the future: (a) computer simulation / visualization / animation of unvisible and extremely complicated physical processes, as those of many particles realistic systems dominated by stochastic processes and described by probabilistic modeling, (b) computer interfacing with the real kosmos through sensors or/and actuators. These two applications could ameliorate –even legitimize– the use of information technologies education in science and technology education.

Simulation / Visualization / Animation of Scientific Models and Technological Applications

Many bodies realistic systems, such as those consisting microkosmos and creating / ruling all physical phenomena of macrokosmos, as well as the operation of many technological applications are not easily represented / taught on the blackboard. Realistic systems of microkosmos are usually very complex, consisting of large number of parameters and operating in a probabilistic and uncertain way. In addition, most of those physical realistic systems are not easily (or even not at all) observable in common educational laboratories whilst are not observable in nature. To study (teach / learn) them, which means to find, confirm, interpret, understand their properties and time evolution, we have to: (a) model them, which to say to distinguish their parts or/and sub processes and analyze them step by step, (b) simulate them by the computer, using special methods / techniques and (c) equally important, visualize by animation (whenever feasible) the way the systems behave according to the simulation.

Apart from the complexity of the real system of microkosmos, due to the great number of their particles and parameters, it has to be noticed, also, that the processes, which are dominating these systems, are "stochastic processes". This means that each state of the systems is not strictly related to the previous state(s). The stochastic character of these systems provokes an additional problem in teaching them on the blackboard, even in an analytical way.

The stochastic character of the microkosmos processes, as well as of the processes of any real, many bodies system requires the use of statistical methods / models, by means of random numbers obeying to specific probability distributions, in other words, requires "probabilistic modeling". This means that the models are mathematical ones, which is to say that their properties are represented by quantitative variables, the latest however taking their values not from strictly calculated tables but among the values given by specified probability distributions. The distributions, of course, are specified according to certain observations / measurements and current theories. So, the models represent as close as possible the world processes, reacting as close as possible to the changes with the uncertain of the reality.

This kind of modeling, although long well-known and widely used in scientific research, only rarely appears to be used for *simulation* and *animation* (or *visualization* by animation) by the computer in education as well till now, since the presence / availability of powerful enough computers in schools is a recent achievement. Models describing complex realistic systems, dominated by stochastic processes, may easily be simulated (and animated, whenever feasible) by nowadays school computers. Statistical methods, like Monte Carlo methods / techniques [6], which obtain estimates of the solution of mathematical models by means of (pseudo) random numbers generated by the computer and formulated according to proper distributions, provide the methodology. So, teachers and students have the chance to "open" inside the classroom a window to non-observable parts and phenomena of our world (especially of the microworld) and follow step by step its processes, in order to improve teacher's understanding / teaching and student's learning. Especially important is that Monte Carlo simulation / animation programs do not simply visualize micro-kosmos structure / processes –in a hypothetical and artistic manner, as it happens usually on static pictures or video / computer screens– based on the scientist's or the programmer's imagination. Instead, they "recreate" them, giving the most accurate approach and perceptibility of the complex reality, based on the models in use, even those of the greatest complexity.

Concerning the probabilistic *modeling* and *simulation* parts of the proposed sequence / procedure, apart from their necessity –in our opinion– in studying / teaching real phenomena, they are essential, also: (i) for extending factual knowledge with the procedural one, that is to say the strategies, tactics and techniques which are necessary?? to use the models, (ii) for introducing profitably computational physics in education and serving as good examples for probability issues, (iii) for giving the possibility of "turning on and off" processes and judging about their contribution to the phenomenon, and (iv) for convincing the students that the real world is not as relentlessly deterministic, as they might expect from newtonian mechanics. Furthermore, the statistical estimates of the outcoming results can be: (v) compared to the results of the real experiments (if it is possible to establish equivalence), allowing the tuning of the parameters and even judging models accuracy (a process which can gradually enhance teaching with research methodology), and (vi) extrapolated to extreme regions or parameters values, allowing predictions of the system behavior under unusual conditions.

Concerning *visualization / animation*, we believe that it is an equally important part: (i) for giving a direct glimpse to the details of complex realistic systems operation, (ii) for being, undoubtedly, an educationally effective means, (iii) for providing animated, non-static pictures representing the reality as closed (according to the current scientific models) as possible. Monte Carlo simulation / animation programs do not simply visualize –in a hypothetical and artistic manner– physical random processes but indeed they "recreate" them, giving the most accurate approach and perceptibility of the complex reality based on the models in use, even those of the greatest complexity. So, teachers and students have the chance to "open" inside a classroom a window to non-observable parts and phenomena of our world and follow their structures and processes step by step.

A number of applications [21,22] reinforce our appeal in the form of computer educational software / programs, dealing with various processes of microkosmos. This software is designed and developed according to the proposed teaching / learning strategy, then tested and evaluated in situ with students of all levels of education (elementary, secondary, university), as well as with in-service training teachers (general and science).

Most of those applications, [21], are referred to processes of microkosmos (and their corresponding phenomena of macrokosmos) as they are proposed by classical models (molecule diffusion phenomena, osmotic phenomena, buoyancy, electric current,...). One application, [22], is referred to the neoclassical / quantum physics approach of hydrogen atom's orbitals.

Computer Interfacing with real Kosmos through Sensors or/and Actuators

A common science and technology laboratory, which implements supplementarilly computers interfacing with the experimental apparatuses through sensors or/and actuators (traditional plus computer-based laboratory), is proposed.

The advantages of a computer-based laboratory can be grouped in three categories:

a) Those resulting to the analysis of phenomena in real time: Performing the experiment in real time makes it more tangible and approachable? to students. It also eliminates the delay between the obtainment of data and their initial analysis. So the student can: (i) repeat the experiment as many times as he or the teacher needs, spending considerably less time, (ii) change the settings of the experiment in order to perform different experimental situations, in order to analyse the influence of some parameters on the phenomenon in a short period of time.

b) Those relating to the sensibility and accuracy of the data acquisition process: The use of the computer-based-laboratory technology allows the studying of very short-time (tenths of second or even less) and very long-time (up to several hours) phenomena that are considerably more difficult to perform by means of traditional technology. It also (i) makes evident the necessity of eliminating the backgroung noise interfering with the main and significant signal, fascilitating the discession about the distinction between the obtained data and the model we use to describe or interpret phenomena., (ii) allows the student to recognize the ideal experiments in textbooks as an extrapolation of several complex real situations, and (iii) in reverse, it helps the student to make approximations and choose the best representations.

c) Those relating the "plasticity" of technology: The computer-based laboratory technology can be used under almost all the different pedagogical visions of the practical work. Although its use does not guarantee the quality of the educative process, it helps to get it.

Teacher-student and student-student interactions are of vital importance in the learning process, and the use of the computer-based laboratory technology gives us the opportunity to reinforce these interactions:

(a) making the data acquisition and processing easy and fast (so that, much more time can be dedicated to the above interactions)

(b) allowing the coexistence of different working levels in the lab, respecting the diversity of the students' learning rhythms

(c) improving the motivation of inquiring activities in the students

(d) offering interesting tools for the empirical data processing (tabulation, graphication, spreadsheets,...)

Moreover, the use of computer-based laboratory familiarize students with the contemporary technologies of automation and robotics, uncovering some "black boxes" of nowadays everyday life. From the educational point of view, what is recommended it the reaction of microkosmos simulation / visualization programs with the real physical parameters through sensors and actuators interfacing with the computer at the same time.

Even though all the above are advantages in order to use technology in our labs, there must be a discussion about which are the best conditions to implement it, and which are the best ones to keep on using the traditional technologies.

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Teaching Conceptual Physics Through Technology

Adam Niculescu and Peter Martin
Virginia Commonwealth University, Richmond, Virginia, USA
vnicule@saturn.vcu.edu, pmartin@saturn.vcu.edu

INTRODUCTION

"Among the many new challenges facing the United Sates physics community is the need to convince the public, and the Congress, of the excitement and the importance of what we're doing". This opinion of James Langer (2000), the current president of the American Physical Society, mirrors many of the recent calls to revitalize the undergraduate physics curriculum. A national task force has found that physics is "…increasingly disconnected from societal needs and federal priorities" (Hilborn, 2000), and a large percentage of the students switching away from science and mathematics have cited "turned off science" as one of their reasons for changing studies (Seymour, 1995). This problem is not isolated to the USA. A survey of pre-college students in China (Liu, 2000) reported that 46% of the students thought physics difficult and not associated with everyday life, with one comment translated to read, "…understanding physics is harder than climbing the staircase to heaven". Most physics-teaching faculty have found, or are finding, excitement in understanding physics, predicting how a system will behave, or experimentally measuring system responses. One of the needs of physics education is to convey this enthusiasm back to the students; to the post-graduate who has committed to pursue a career in science, to the physics major who may be looking for reasons to stay "turned-on science", and also to the non-science student who finds it difficult to relate physics to everyday life. Even though the latter will not be the scientist of tomorrow he/she could be the person approving science funding, or preparing media reports on the role of technology, or more likely, just part of the population that could appreciate the value of supporting science.

At Virginia Commonwealth University (VCU) the commitment to improved instruction led to the development and implementation of a new General Education curriculum that stresses increased science literacy. VCU's College of Humanities and Sciences set out to create new models of college level instruction and pre-service education using interdisciplinary and multidisciplinary science courses. In the area of physics, a new conceptual physics course aimed at non-science majors was developed entitled *Wonders of Technology*. The textbook, developed in conjunction with the course, was published by John Wiley & Sons in 1999 and now is in its second edition

(Niculescu, 2000).

The present article describes the main features of the course that made it very popular on campus, and also the results of evaluation instruments developed to assess the students' progress in the understanding of physical concepts.

COURSE DESCRIPTION

'Wonders of Technology' is a one-semester laboratory-based course. The approach taken in the introduction of the physical concepts is by depicting their role in today's technology, specifically the technology familiar to the students, and also to emphasize the connection between technology, art and culture from a historical perspective.

The students achieve science literacy by studying the processes, concepts, and underlying principles of modern experimental science and technology without the numbing constraint of having to obtain the exact "correct" answer. They also are required to apply the material learned in class to every-day applications, to draw conclusions from their own experimental observations and to use their own results in a *design* or *discovery* phase for each studio. Activities and tests encourage development of the mental skills necessary to think scientifically; the ability to understand and respond critically to science articles and programs in the popular media, and give the students some understanding of how science relates to religion, ethics, politics, economics, and the arts.

The unit format stresses a project/laboratory/hands-on approach, with high student involvement. The course has a lecture component and a studio component. The studio component lasts 3 hours each week and is given in small sections with no more than 26 students, whereas the lecture component is given simultaneously to several sections and lasts one hour per week. By keeping the studio section size low each student receives individual attention and by necessity must contribute to the projects.

The *lecture component* is multimedia and interactive. At the start there is a short review of any late-breaking news from the world of science and technology. During the rest of this period the students are introduced to topics from life-related experiences, using films, demos, simulations, etc. A particularly effective method used to introduce new concepts during the lecture period is to integrate several multimedia components together. For example, when introducing the topic dealing with the effect of electric and magnetic fields on charged particles within the magneto-hydrodynamic propulsion, the sequence starts with a short movie, followed by a live demonstration of the magneto-hydrodynamic effect on the overhead projector. This is followed by a detailed explanation of the physical principles by using a PowerPoint presentation.

The *studio component* normally starts with a short quiz covering all of the previous week's work. There is then an interactive review of the collective results from the previous weeks project, including the relevance to personal life and other technology. This is followed by any instruction that is needed on the principles, or mechanics, of the project that will follow. The students work in groups of 2-4 people, on projects that have relevance to the problems raised during the lecture presentations. Cookbook quantitative experiments are avoided, process is emphasized over numerical result, conversation is encouraged, and speculation is rewarded.

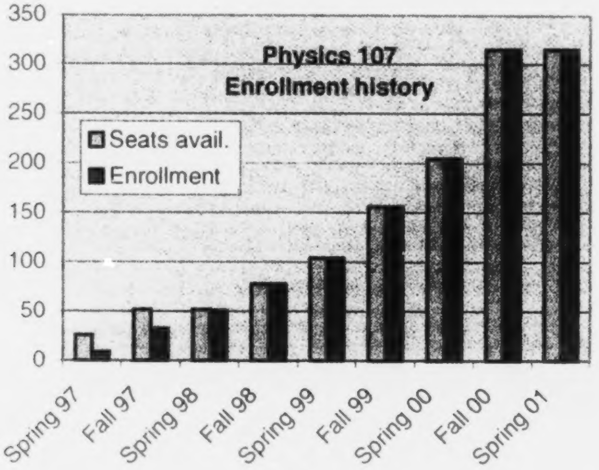

Figure 1. History of Physics 107 Course Enrollments.

DEVELOPMENT

The course was first offered on an experimental basis in the spring 1997. From this tentative start the course enrollment has grown steadily as shown in Figure 1, to a total of 312 students distributed in 12 sections.

The composition of the sections has been monitored carefully. The enrollment by gender has remained very close to 50%.

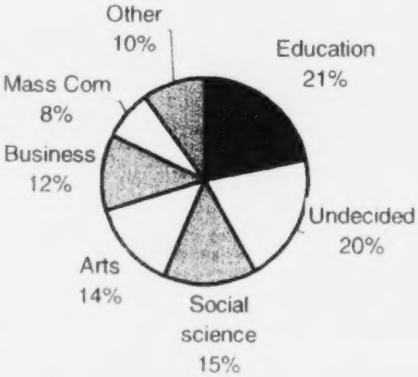

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Figure 2. Student distribution by major.

As far as the enrollment by major, it appears that the Education majors have the top percentage, as shown in Figure 2. To a large extent they feel that they can use the material learnt in Wonders of Technology in their future classroom.

EVALUATION AND ASSESSMENT

The student performance, and consequently the grade, is evaluated through a combination of project reports, self-directed projects, quizzes, homework, and a final evaluation. The final evaluation is part individual project and part written examination. For the final project the students develop individually an independent topic that can be experimental (they build a device or take data with an existing one), theoretical (researching a topic), or both. To the extent possible, it relates physics and technology to the student's major, or sometimes to their interests. Examples of such projects are given in the table below.

Constructing a Tesla coil	Four-color printing process
Studying the harmonics of musical tones	Stage lighting
Making a music synthesizer	Animation showing formation of isometric shapes in cubic crystals.
Light communication instrument	Magneto-hydrodynamic propulsion

Overall the students consider the projects as an asset to this course, and they realize that physics IS indeed part of their life and career.

In a large study, Hake (1998) investigated achievement of students who were taught under traditional instruction and interactive engagement. His sample included 62 introductory high school and college physics classes (N = 6542). Hake analyzed the data in terms of a ratio of percent gain to maximum percent gain from pre-test to post-test using the Force Concept Inventory (FCI) scores. This gain is now referred to as the Hake factor (authors refer to this as *h* or *g*). The following equation shows how the Hake factor is calculated.

$$h = \frac{\%\ \text{post-test} - \%\ \text{pre-test}}{100 - \%\ \text{pre-test}}$$

Data was categorized as either Interactive Engagement (IE) or Traditional (T) type courses. Courses that were categorized as IE "promote conceptual understanding through interactive engagement of students in heads-on (always) and hands-on (usually) activities, which yield immediate feedback through discussion with peers and/or instructors." Courses that were categorized as a T "make little or no use of IE methods, relying primarily on passive-student lectures, recipe labs, and algorithmic-problem exams" (Hake, 1998). There were 56 courses (N = 4458) that were categorized as IE and 14 courses (N = 2084) that were categorized as T.

Hake factors (h) were grouped into three categories: low gain (<0.3), medium gain (0.3-0.7) and high gain (>0.7). He found that all 14 T courses fell in the low gain region (h = 0.23 ± 0.04. IE courses fell mostly (85%) in the medium gain region, while 15% fell into the low gain region. In the average the gain was *h* = 0.48 ± 0.14.

We attempted to develop an instrument that would assess students' progress throughout the semester by administering them a 14 questions test from topics that are covered during the term. The questions were given in the first week of classes and again at the end of the semester as part of the final exam. The test was first administered in the spring of 2000 to 188 students, and contained 14 open-ended questions. The response of the students was processed for each individual question. This way we could use the test as a diagnostic tool to indicate what topics present more difficulties in understanding for this category of students, and to determine where we could improve on the method of delivery and content of the topic. The results are displayed in the Figure 3. The overall gain (*h*) was 0.5, which falls within the mid-range of Hake's analysis (mechanics only) for IE courses. The test was re-administered to the fall 2000 class with 254 students responding. Due to limitations in manpower and the increased enrollment, the test was given in multiple-choice format with the content of the questions unchanged. It is to be noted that the profile of the gains for the answers is roughly the same as for spring 2000, however the results are slightly lower than for the open-ended questions, with an overall normalized gain of 0.36. Subjectivity in the grading of the open-ended test aside, we feel that the better results with open-ended questions (the students were given 10 quizzes in this format throughout the semester) are due in part to the better training of the students to think out the answers as opposed to relying in part to guessing of the correct answer.

In the spring 2001 we have modified the quiz to exclude topics that were already well understood by the students and to cover a wider range of topics. We have also used the results to modify instructions and general aspects of physics.

Virginia Coalition for Excellence in the Preparation of Teachers (VCEPT) is a National Science Foundation's - funded project aimed at identifying and implementing "best practices" for college science and science instruction. VCEPT administered surveys in 1998, 1999, and 2000 to determine student assessment of the *Wonders of Technology*. The results of the questionnaire given in the fall 2000 to 254 students are summarized in the table below[1]. The students used five-point rating scales to describe the presence and value of course characteristics:

Presence: "To what degree did the classes in this course include ..."

Value: "To what degree are these course characteristics important in helping you learn in this course?"

---

[1] The data was processed by Dr. George Bass, College of William and Mary.

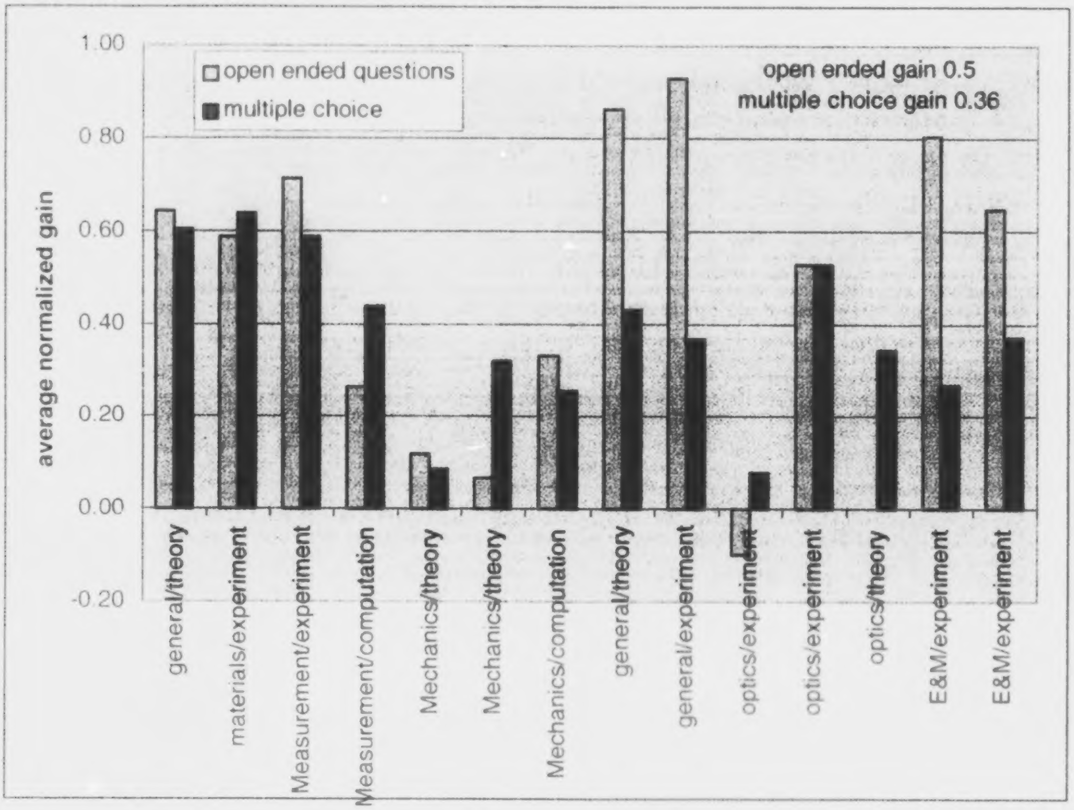

Figure 2. Student distribution by major.

Presence [%]
A = Systematic use (100% of classes)
B = Customary use (75%-99% of classes)
C = Frequent use (50%-74% of classes)
D = Moderate use (25-49% of classes)
E = Occasional use (0-24% of classes)

Value [%]
A = Very Important
B = Important
C = Unimportant
D = Detrimental to your learning
E = Not Applicable or No Opinion

	Presence					Value				
	A	B	C	D	E	A	B	C	D	E
1. active student learning	64	23	12	3	.01	68	27	3	1	0
2. up-to-date teaching technologies	36	43	9	6	2	43	45	9	1	4
3. connections to other related disciplines	29	38	22	7	4	29	54	11	2	3
4. connections to the natural world	45	32	5	8	0	38	48	11	1	.004
5. mixture of breadth and depth in coverage	24	44	24	6	.01	35	48	12	.004	.004
6. interesting and intellectually involving concepts	39	39	13	6	2	56	35	5	.01	.01
7. critical thinking about current events	22	31	31	10	5	31	40	22	3	2
8. practical applications to students' own lives	23	37	26	9	4	37	35	13	2	.004
9. effective interactions among students	55	29	10	5	.004	54	34	9	1	1
10. opportunities to collect pertinent information	34	40	17	6	2	37	48	11	1	.01

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11. opportunities to organize information	32	41	20	4	2	38	49	9	1	.01
12. opportunities to analyze information	41	36	17	3	2	43	46	7	1	1
13. opportunities to communicate conclusions and ideas	34	36	20	5	2	43	47	5	2	2
14. ethical and social implications in the world	15	41	26	13	7	31	42	18	3	5
15. assessment of student performance in different ways	26	40	19	9	4	44	44	7	2	2

The academic classification at the beginning of the 2000 fall semester was the following:

Freshman - 43% Sophomore - 21% Junior -16% Senior -16% Graduate or Unclassified -2%

SUMMARY

The positive evaluations of the course by students, the strong recommendations given by peers and student advisors and the early filling of the course enrollment, suggest the course is achieving its goals: improving the scientific literacy of the students, relating science to the students' everyday lives and being an enjoyable course to have studied.

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Learning Technology Systems: Issues, Trends, Challenges

P. Avgeriou and A. Papasalouros, University of Athens, Greece
pavger, and papas@softlab.ntua.gr
S. Retalis, University of Cyprus, Cyprus
retal@softlab.ntua.gr

ABSTRACT

This paper elaborates on a comparative analysis of contemporary LTSs. We have selected a number of the most important, commonly used, modern LTSs and put them through a thorough evaluation process, based on the services, tools, and features they support, and the usability of their hypertext user interface. The result of the evaluation is twofold: to explore the utility of LTSs and consequently discover the real nature of these systems, based on the features they support; and to delve into the usability of LTSs, a critical factor in the acceptance of these systems by the market.

Keywords

Learning technology systems, distance learning, computer-based training, hypertext, evaluation, usability.

1. Introduction

The introduction of networked technologies and especially the Internet and the World Wide Web in the fields of education and training, is not new and certainly not innovative. In fact these technologies, also known as 'Advanced Learning Technologies' [http://csalt.lancs.ac.uk/alt/], have been around for some years, and have been applied in the form of computer-based training, electronic performance support systems, computer assisted instruction, intelligent tutoring, collaborative, adaptive and distance learning etc. Even though the Internet and the Web are the basic low-level infrastructure for the construction of such systems, there is also a middleware in the form of **Learning Technology Systems (LTS)** that provides integrated services such as the creation and distribution of on-line learning material, the communication and collaboration between the stakeholders, the management of instructional systems and so forth. These systems incorporate fundamental Internet and Web services, provide a uniform interface to learners, tutors, learning material authors, instructional designers and administrators, and promote portability of learning resources as well as interoperability between each other.

The LTS [IEEE LTSC 2000] has been established as the basic infrastructure for supporting the technology-based instructional process in an easy-to-use, pedagogically correct and cost-efficient manner. LTSs have been used for educational and training purposes, not only because they have been advertised as the state of the art learning technology, but also because they have substantial benefits to offer. In specific, they alleviate the constraints of time and place of learning, they provide an excellent degree of flexibility concerning the way of learning, they support advanced interactivity between tutors and learners and they grant one-stop maintenance and reusability of resources.

The plethora of the LTSs available today, as well as the varying needs of instructional systems, instructors and institutions, create a need for the evaluation of these systems, so that their potential can be investigated [Alexander 1995]. The market is packed with such systems that offer different services and capabilities regarding organization and distribution of learning content, course management, student assessment, communication and collaboration tools, administration of instructional institutions and so forth. There has to be some comparative analysis and assessment of LTSs, which clearly probes their features in the context of pedagogy, open learning and instructional design. Consequently instructional designers that are called upon to solve a specific instructional problem with explicit needs and requirements will be assisted in choosing a specific LTS that fits closer to the above problem.

A number of comparative reviews are available on the World Wide Web. The most important are

- [http://www.ctt.bc.ca/landonline], a comprehensive presentation of technical characteristics of LTSs, and an on-line tool for automatic comparison of systems, based on certain criteria.
- [http://www.leeds.ac.uk/educol/documents/00001237.htm, etc], a review that provides a full framework for the evaluation of LTSs based on Pedagogy and System Organization applied on 12 systems.
- [http://www1.umn.edu/dmc/portfolio/comparison/index.shtml], where four LTSs are being examined against certain, high level evaluation criteria. The results are presented in textual interview reports and comparative evaluations per system and per criterion.
- [http://www.esocrates.com/LearningResources/ComparisonChart.htm] [http://www.marshall.edu/it/cit/webct/compare/comparison.html] [http://www.umanitoba.ca/ip/tools/courseware/evalmain.html] [http://www.futureu.com/cmscomp/cmstables.html#table1]. These Web Sites present tables of features supported by selected LTSs.

These reviews usually focus on the mere presentation of the features supported by the LTSs being examined, as well as on the comparison between them according to specific criteria. Some times an evaluation framework is introduced, based on technical and pedagogical principles. This paper also presents an evaluation framework that is concentrated on technical specifications, as well as on usability issues. For every learning technology system assessed, there is an analytical table of features and functions categorized in groups that address the most important functions that these systems are expected to perform, as well as other features, such as standards compliance [Nielsen 200]. Also there is a classification of the LTSs under assessment, according to the features they best support and the potential need that we suggest they can address in the learning process. Finally usability criteria are adopted in order to further assess the systems functionality and efficiency in addressing the needs of different types of users accessing the systems.

The aim of this review is not a mere lining up of the different capabilities that LTSs offer at present, but also an investigation regarding the trends of the market, the worries about the problems that surface, and finally the challenges that are currently faced. The structure of the paper will be as follows: In section 2 we describe in detail the framework used for the evaluation. Section 3 presents the qualitative results of the assessment of LTSs, while section 4 continues with some conclusions deduced from the review.

2. *Evaluation framework*

Our approach derives from the understanding that Learning Technology Systems are introduced and widely adopted by institutions and instructional designers, in order to fulfill certain needs and requirements in a field of ever increasing demands for effective, fast and pedagogically correct education and training. Consequently the people involved in the decision-making process concerning instructional design and organization of educational institutions would use a Learning Technology System in order to:

- Create, operate and administrate an on-line course.
- Support the collaboration between students and provide motivation and resources for team building [McConnell 1994].
- Create and deliver questions and tests for student assessment
- Organize educational, financial and human resources.
- Administer virtual, distributed classes where the students are geographically scattered and communicate via the Internet.

These diverse usage scenarios of LTSs, correspond to different categories of Learning Technology Systems, which are respectively the following:

- **General systems,** which have a number of tools for creating and managing courses and do not give emphasis to any particular set of features. We call these systems 'general' and not, for example 'Course Management', because they provide a plethora of features that span many assorted areas, in order to provide fully functional on-line courses, such as communication tools, administration tools, etc.
- **Collaborative learning support systems,** which emphasize on team building, student group management and providing the synchronous and asynchronous collaboration tools to support the aforementioned activities.
- **Question and test authoring and management systems,** which facilitate the design and construction of quizzes and tests, which are published on the WWW and

taken on-line. They provide tools for test creation and their on-line delivery, automatic grading, results manipulation and report generation.

- **People and Institute resources management systems,** which deal with human resources and financial management.
- **Virtual classrooms,** which establish a virtual space for live interaction between all the participants in the learning process, i.e. instructors, tutors and students.

The LTSs that fit in one of the above categories support a number of **features**, or tools or capabilities in order to carry out certain tasks. These features do not discretely belong to only one LTS category but can be shared by several categories. These features can be classified into certain groups, namely:

- **Course Management,** which contains features for the creation, customization, administration and monitoring of courses.
- **Class Management,** which contains features for user management, team building, projects assignments etc.
- **Communication Tools,** which contains features for synchronous and asynchronous communication such as e-mail, chat, discussion fora, audio/video-conferencing, announcements and synchronous collaborative facilities (desktop, file and application sharing, whiteboard).
- **Student Tools,** which provide features to support students into managing and studying the learning resources, such as private & public annotations, highlights, bookmarks, off-line studying, log of personal history, search engines etc.
- **Content Management,** which provide features for content authoring and delivery and file management.
- **Assessment Tools,** which provides features for managing on-line quizzes and tests, project deliverables, self-assessment exercises and so on.
- **School-Management,** which provide features for managing records, absences, grades, student registrations, financial administration etc.

The features in these groups are presented in the next paragraph. The first part of the evaluation framework aims at two goals: a) to discover *what* an LTS does, i.e. which features it supports and b) to classify the LTSs into the appropriate categories. The first goal is achieved by providing tables of features and ticking the suitable check-boxes for every LTS. The second goal is accomplished by identifying the groups of features that an LTS supports and deciding about which one of the LTS categories it belongs to. This decision is not taken ad hoc, but according to the mapping of Table 1. This mapping portrays the relation between the aforementioned Learning Technology Systems categories and the groups of features that we have selected in order to characterize the LTSs.

The classification of LTSs under evaluation into categories is of paramount importance since it seeks to shed some light into the real nature of these systems, as there is currently much confusion about this matter. The terms used to describe the LTSs are covered by much vagueness and fuzziness and companies or other development organizations tend to assert these systems with expressions that further augment the uncertainty. There is surely no common vocabulary that characterizes the LTSs, which results in hindering the building of consensus among various stakeholders. Our approach aims to clarify things by characterizing LTSs objectively, according to the features they support.

The evaluation framework proposed in this paper suggests that the systems under evaluation shall be tested in order to discover the supported features and consequently the supported groups of features. If the majority of the features in a group is supported by an LTS, then the whole group is considered to be supported by this LTS. The result will be to classify the LTSs into the respective categories according to which groups of features they support and the mapping of Table 1. An important issue that must be emphasized here is that it is possible for an LTS to fit into more than one category, i.e. it can be used for more than one purposes.

Table 1: Mapping between LTS categories and groups of features

LTS Categories Supported Groups of Features	General Systems	Collaborative Learning Support Systems	Virtual Classrooms	Question and Test Authoring & Management Systems	People and Institute Resources Management Systems
Course Management	X				X
Class Management	X	X	X		X
Communication Tools	X	X	X		
Student Tools	X	X	X	X	
Content Management	X			X	X
Assessment Tools	X			X	
School- Management	X				X

The evaluation framework so far has dealt with the utility of the LTSs by proposing the identification of features that each LTS supports, and the classification of the LTSs into the defined categories. The second part of the framework deals with the usability of the LTSs, which is not concerned with *which* features are supported by each LTS, but *how well* they are supported. This approach is based on the hypertext usability criteria proposed in [Nielsen 1993], takes under account the evaluation principles suggested in [Tessmer 1996], and elaborates on the above in order to set usability criteria especially for Learning Technology Systems.

LTSs are complicated hypertext systems having extended and complex navigation structure in order to present the learning content and tools that they provide. The intricacy of hypermedia applications has become common knowledge and there are various techniques and models used in order to manage this structural and semantic complexity [Squires & Preece, 1999, Lowe & Hall 1999]. The criteria proposed by this evaluation framework aim to address the usability issues that cover the whole of the multifaceted hypermedia-based LTSs and are the following:

1) **Easy to learn and comprehend.** The users of an LTS must easily comprehend the system and learn how to use it. This concerns the navigation, the selection of tools and functions and the metaphors. It is also important that special technical skills are not required.
2) **Efficient in feature realization**. LTSs are designed to perform certain tasks, but it is obvious that not all LTSs perform the same tasks in the same manner (e.g. the video conferencing facility in CUSEEME and Microsoft Netmeeting). The question here is how well are the various tasks being performed.
3) **Efficient in navigation.** A user who is navigating through the hypermedia structure of an LTS must at all times know where he is and why he is there, where he came from and where can he go from there.
4) **Forgiveness from errors**. A user of an LTS often navigates himself back and forth through various paths due to an inclination to experimenting and exploration. A forgiving system allows the user to return quickly and easily to the point where he started through commands such as "undo", "back", "revert" etc.
5) **Pleasant to use**. An LTS must have pleasant aesthetics, which is the result of the color code in use, the graphics and animation quality, the fonts etc. An LTS is also pleasant to use when the downloading and the transition between pages of content is fast, or in other words when the user is not forced into frustrating delays.

For each of the above criteria we apply a grade from 1 to 5 where a small number means poor performance and a large one means good performance. This sort of usability evaluation is performed for each category of potential users, namely the students, the designers, the tutors and the administrators. This is important because different categories of users are provided with different kind of features, and even the features that are shared by more than one user categories have different user interfaces for each one of them. The application of this evaluation framework for 13 Learning Technology Systems is described in the following section.

3. Results

We have selected a certain number of LTSs for applying the proposed evaluation framework. The criteria for selecting the specific systems out of the entirety of the LTSs in the market are: a) the degree of adoption they have received by instructional institutions and b) the availability of resources for our evaluation (on-line documentation, white papers and demonstration versions of the systems). We concluded in 13 LTSs, that we consider being the most widely adopted in the educational market and that also offer adequate resources for their evaluation.

The proposed evaluation process begins with testing each system and checking which features it supports. These features are classified into the groups mentioned in Section 2. The results are depicted in Table 2.

Course management	**WebCT**	**VirtualU**	**Blackboard**	**CoSE**	**Centra**	**Cate**	**Intralearn**	**TopClass**	**LearnLinc**	**Saba**	**FirstClass**	**Convene**	**LearningSpace**
Syllabus Template	No	Yes	No	No	No	Yes	Yes	No	No	No	No	Yes	No
Calendar	Yes	Yes	Yes	No	No	Yes	Yes	No	No	No	No	Yes	Yes
Announcements	Yes	No	Yes	No	No	No	Yes	Yes	Yes	No	No	Yes	No
Glossary	Yes	Yes	No	No	No	No	Yes	No	No	No	No		No
Structure course access pages	Yes	No	Yes	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Customizable-consistent course interface	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Links to web resources	Yes		Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Class Management													
Create assignments	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Organize students in groups for team working on assignment projects	Yes	No	Yes	Yes	No	No	No	No	No		Yes	Yes	Yes
Assignments grading	Yes	Yes	Yes	No	No		Yes	No	No	Yes	Yes	Yes	Yes
Assignments grades statistical analysis	Yes	Yes	Yes	No	No		Yes	No	No	Yes	Yes	Yes	
Students' progress tracking	Yes	No	Yes	No	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Assessment tools													
Test content authoring tools/wizards	Yes	No	Yes	Yes	No	No	No	No	Yes	No	No	Yes	Yes
Test content upload	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Automatic, scheduled test delivery.	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	Yes	
Automatic test scoring	Yes	No	No	No	Yes	No	Yes	Yes	Yes	Yes	No		Yes
Automatic generation of results' statistical analysis reports.	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes

Number of test types supported	5	Any	4	0			3	>4	5	5	0	>4	4
Advanced security for increased examination procedure's reliability.	Yes	No	No	No	No	No	No	No	No	Yes	No	No	Yes
Automatic generation of quizzes from a pool	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No		Yes
Adaptive and personalized quiz presentation	No	No	No	No	No	No		Yes	No	No	No		No
Communication tools													
E-mail	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes
Chat	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	No	Yes
Discussion forums	Yes	Yes	Yes	No	Yes	No	Yes	Yes		No	Yes	Yes	Yes
Video conference	No	No	No	No	Yes	No	No	No	Yes	No	No	No	No
Voice conference	No	No	No	No	Yes	No	No	No	Yes	No	No	No	No
Shared white board	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	No	No	No	No
Application Sharing	No	No	No	No	Yes	No	Yes	No	Yes	No	No	No	No
Sessions scheduling	No	No	No	No	Yes	No	No	No	Yes	No	No	No	No
File transfer utilities	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Student Tools													
Add Bookmarks	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes		Yes
Add Personal notes	No	No	No	Yes	No	?	Yes		No	No	Yes		Yes
Get information about study progress	Yes	Yes	Yes	No	No	Yes	Yes		No	Yes	Yes		Yes
Self-assessment quizzes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No		Yes
Adaptive/personalized quiz presentation	No	No	No	No		No	No	Yes	No	Yes	No		No
Search-in-content tools	Yes	No	No	Yes		No?	Yes	Yes	No	No	No		No
Self registration in courses	Yes	No	Yes	No	No	Yes		Yes	Yes	No	No		No
Personal web page creation	Yes	No	Yes	No	Yes		No		No	No	Yes		Yes
View his own grades	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes			Yes
Groups of students can share resources to facilitate team working.	No	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
Content management													
Content upload	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Content authoring	Yes	No	No	Yes	No	No	No	No	No	No	Yes		No
Content structuring	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	No	Yes		Yes

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Multimedia content insertion	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Other (than html) content types supported	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes		Yes
Tools for effective navigation inside content	Yes	No	No	Yes	No	Yes	Yes	Yes	No	Yes	No		Yes
No HTML knowledge required for content authoring	No	No	No	Yes	No	No	No	No	No	No	Yes		No
Tools/wizard for content authoring	No	No	No	Yes	No	No	No	No	No	No	Yes		No
Use of templates – reusability of content appearance	No	No	No	No	No	No	No	No	No	No	Yes		No
Tools/wizards for content publishing	No	No	No	Yes	No	No?	Yes	Yes	No	Yes	Yes		No
Meta-data specification.	No	No	No	Yes	No	No		Yes	Yes	Yes			Yes
School-Organization Management													
Student admissions management	No	No	No	No	No	Yes	No	No	No	Yes	No	No	No
Human resources management	No	No	No	No	No	Yes	No	No	No	Yes	No	No	No
School financial management support	No	No	No	No	No	No	No	No	No	Yes	No	No	No
Student mentoring – Advising for courses selection and prerequisites	No	No	No	No	No	No	No	No	No	Yes	No	No	No
Administration													
User Records Management	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No		Yes
Course Backups	Yes	No		No	No	No	Yes	No	No		No	Yes	No
File management support	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	No		No
Database management support	No	Yes	No	No	No	Yes	Yes		No	Yes	No		No
Other Features													
General													
Multiple language support	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No		No

Learning technology standards compliance	IMS	No	IMS	IMS	No	No	AICC, SCORM, IMS	AICC, IMS	No	AICC IMS, IEEE	No	No	AICC, IMS
Online help	Yes	Yes	Yes				Yes	Yes	Yes		No	Yes	Yes
Reliable technical support	Yes		Yes				Yes			Yes	No	Yes	Yes
Price	$4,000 (400 Students)	$2500 (Academic Price)	$4000	£2495 (Unlimited package)			$25,000						
Technical													
Web hosting /Local server installation	Local	Local	Local/Hosting	Local	Local	Local	Local		Local	Local /Hosting		Web hosting	Local
Database System Use	No	No	No	No		Yes	Yes		Yes	Yes	No		Yes
Server platform requirements	Unix/Win	Unix/Win	Unix/Win	Unix/ Win	Win NT/2000	WinNT	Win NT/2000	Win/ Unix/ Mac	Win	Win	Win		Win
Openness	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	No	No	No
Assessment Resources													
Tested Product/Version	v.3.1.3	v.2.5	v.5				SMS		v.5	Learning Enterprise	Zebu	Izio	v.4
Method of Assessment	Full functional local installation	Full functional local installation	Full functional Online demo	Partially functional Online demo – Downloaded documentation	Downloaded documentation	Partially functional Online demo – Downloaded documentation	Partially functional Online demo – Downloaded documentation	Downloaded documentation	Partially functional Online demo – Downloaded documentation	Downloaded documentation	Partially functional Online demo – Downloaded documentation	Partially functional Online demo – Downloaded documentation	Partially functional Online demo – Downloaded documentation

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It is reminded that we consider a group of criteria to be supported by an LTS if the majority of features in the group is supported. In Table 2, the features mentioned as 'Other Features' have not been taken into account for the classification and are presented for informative reasons only. Taking into account the mapping between the categories of LTSs and the groups of Features, as shown in Table 1, we classify the systems in the categories defined in Section 2. The results are shown in Table 3.

Table 3: Learning Technology Systems Categorization Results

Name	Company	URL
General		
WebCT	University of British Columbia	http://www.webct.com
CoSE	Staffordshire University	http://www.staffs.ac.uk/COSE
Centra	Centra Software	http://www.centra.com
Cate	Cate	http://www.cate.com
Convene	Convene	http://www.convene.com
LearningSpace	Lotus	http://www.lotus.com/home.nsf/welcome/learnspace/
BlackBoard	Blackboard	http://www.blackboard.com
TopClass	WBT Systems	http://www.wbtsystems.com
VirtualU	Virtual Learning Enviroments	http://www.vlei.com
FirstClass (Zebu)	Centrinity	http://www.firstclass.com
Intralearn	Intralearn	http://www.intralearn.com
Collaborative Learning		
WebCT		
BlackBoard		
Virtual Classrooms		
LearnLinc	Mentergy	http://www.embanet.com
Question and Test		
WebCT		
Organisational Management		
Cate	Eurocom	http://www.eurocom.gr/catesite/

As we have mentioned above, some systems can be classified into more than one categories, which is rather evident in Table 3. For example, WebCT can be used both as a general purpose system, and as a system that provides a full set of tools to create and deliver Questions and Tests.

As far as the usability evaluation is concerned, we used the criteria described in the previous section to test five of the most dominant systems of the 'General' category: WebCT, Blackboard, VirtualU, Intralearn, LearningSpace and CoSE. We only tested systems from the 'General' category because of the wide adoption of this category and the extensive hypertext user interface that characterizes them. We applied our criteria for three types of users: Students (St), Instructors and Designers (ID) and Administrators (Ad). The results of the evaluation are represented in Table 4.

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Table 4: Systems Usability Assessment per User

LTS	Usability Criteria														
	Easy to learn and comprehend			Efficient in feature realization			Efficient in navigation			Forgiveness from errors			Pleasant to use		
	St	ID	Ad	St	ID	Ad	St	ID	Ad	St	ID	Ad	St	ID	Ad
WebCT	5	4	3	4	5	3	5	4	3	3	2	2	5	4	3
Blackboard	5	5		4	4		5	4	3	4	3		4	4	
VirtualU	3	3	3	2	2	2	3	3	3	2	2	2	4	3	3
Intralearn	3			4			4			4			3		
LearningSpace	4			4			4			3			4		
CoSE	2			5			4			4			3		

4. Conclusions

The mere enumeration of supported features, is a good metric for the potential of LTSs, but cannot be an inclusive measure for the comparative analysis and evaluation of Web-based Learning Technology Systems [Avouris et al. 2001, Patern_, 2000]. The added value of our approach is twofold: the classification of the LTSs into categories according to specific objective criteria and the survey of the usability of these systems. The first aspect aims at clarifying the real disposition of the LTS under evaluation, as there is currently little insight, concerning what each of these systems actually represents, what it is able to perform, and what needs it can cover. The second aspect deals with an often-overlooked matter, the usability of the hypertext user interface, which is rather critical in LTSs that are extensively based on human-computer interaction.

From the tables 2 and 3 it is obvious that the most full featured and powerful systems are Blackboard and WebCT. It is not a surprise that these two systems are the most popular in the education and training market at present. Another inference from the tables is that the majority of the systems examined belong to the 'General' category, and these systems include a great variety of features that overlaps all the other categories. Systems that belong to this category are more popular than systems from the other categories, because they tend to have everything in the same price, even if they lack in efficiency compared to the specialized systems.

From Table 4 we conclude that most of the LTSs are characterized by an acceptable degree of usability as far as the student is concerned, and they are less usable for designers, instructors and administrators. This is partially justified by the fact that students are equipped with rather simple and straightforward tools, while designers, instructors and administrators deal with much more complex and dense tools and perform more challenging tasks. On the whole we reckon that the LTSs under evaluation are quite usable, especially as far the 'easy to learn and comprehend' and 'efficient in navigation' criteria are concerned.

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The Need of Broadening Tertiary Level Technological Education in Informatics in Greece. A New Department in Crete

V. Zacharopoulos, I. Xezonakis, C. Athanasaki-Michailidou,
Heraklion, Crete, Greece
vzachar@techmed.teiher.gr, athan@stef.teiher.gr
A. Kourtis, Ag. Paraskevi, Athens, Greece, *koutris@iit.demokritos.gr*
E. Pallis, University of East London, *pallis@iit.demokritos.gr*

Abstract: The 21st century is the century of the information society (I.S.), which is expected to introduce a different kind of development, thus leading to evolution and market competitiveness. Greece will be highly benefited from the I.S., as the new technologies will bring the country closer to central Europe, by fighting against the disadvantage of the "isolated regional country", while reinforcing its development process. The new department of Applied Information Technology and multimedia (AITM) of the Technological Educational Institute (TEI) of Crete aims to contribute with its scientific staff and graduates to the establishment and operation of the I.S. In this paper a feasibility study is presented, that has been conducted towards the drawing up of the curriculum for the new department in terms of the perspective of labor market and the balance between supply and demand concerning professions. Also, some features and ideas are presented, which support the new course concerning mainly new methods of teaching. Furthermore, concerning the two years of operation of the Department some statistical data will be analyzed and reflections on its future and viability will be outlined.

Key words: Engineering education, Future professions, New curriculum, Information society, Technology convergence

1. INTRODUCTION

Convergence of telecommunications and information technologies characterize the current transitional period from the post-industrial era to the information society (I.S), which is expected to offer great new opportunities and result in economic, social, political and psychological changes, in a large scale.

Despite the skepticism that all these changes bring there is a common belief that new technologies can support a different kind of development and lead to an economic robustness and competitive strength. These benefits are mostly true for Greece, given that the elimination of distances, which is the result of the new digital era, brings Greece closer to Europe by making the disadvantage of the isolated country obsolete, while reinforcing its development process.

The new department of Applied Information Technology and Multimedia (AITM)(1,2) of the Technological Educational Institute (TEI) of Crete which was approved by the Ministry of Education under the Operational Program of Education and Initial Professional Training (3) and has been operating since 1999, intends to contribute with its scientific staff and graduates to the establishment and operation of the I.S.

This paper presents a feasibility study that has been conducted towards the drawing up of the curriculum of the new department in terms of the perspective of the labor market and the balance underlying between supply and demand of professions. This curriculum introduces the new converged fields of communication and computer technologies, while gearing the students with the appropriate skills via I) a new method for acquiring technical specialization. The curriculum enables the students to register in several subjects that will provide them (after successful completion) the profession in the field of their choice, and II) a new educational and qualifying system that provides a 'convincing' move towards 'assignment type of assessment' i.e. a report, a case study, a practical exam, group assignment work and the like. Eliminating the exam 'altogether' (wherever possible) clearly offers an advantage to the student but at the same time the only way to pass the lesson is 'by working for it' and since the lectures will support the assignments, one may find that students attend lectures more regularly. Finally, the proposed curriculum support courses that:

- Keep student load within realistic limits and in accordance to other EU countries and practices.
- Increase student choice and flexibility (wherever possible).
- Recognize the changing role of the lecturer to that of a 'facilitator', i.e. moving away from 'chalk and talk' practices.
- Increase 'student centered learning activities'.

Following this introductory section, Section 2 presents the labor market of information in Greece, Section 3 introduces the Informatics science studies in T.E.I., Section 4 introduces the objectives and scientific institutions of the Informatics science in Crete, Section 5 presents the current activities of the AITM department of informatics in Crete, while Section 6 presents some statistical data concerning the two years of operation of the department. Finally, Section 7 concludes the paper.

2. THE LABOR MARKET OF INFORMATION SCIENCE IN GREECE

2.1 Information sources

There are no registered records in Greece, from which market potential and balance of supply and demand of the professions can be estimated. There exist a few published researches carried out by the National Statistical Agency of Greece.

(N.S.A.G), which concern the workforce of the country. However, they are not detailed and not especially useful since they refer to very general categories of the workforce and professions. Some other agencies, they either don't keep useful statistical data concerning the market trends (for example: National Employment Agency), or use the data provided by the N.S.A.G. (for example: Employment Agency of the General Labor Syndicate of Greece).

The absence of such kind of information has created a lot more significant problems than simple incapability of statistical processing, since we don't have the chance of linking the market needs with the educational system. As it estimated by a published research (4), half percentage from the total 10% of the unemployment rate in Greece is due to the incompatibility of the educational system and the market potentials.

2.2 Supply and demand of employment in Informatics

In the research mentioned above (4), the balance of supply and demand concerning professions in the fields of informatics, telecommunication and multimedia has appeared to be between positive and very positive for the five-year period of 1998-2003 and it has been specifically stated: *"these professions are the heart beat of the future"*.

Concerning the informatics graduates, the study showed that University (AEI) graduates are mostly theory-wise trained and need a longer adaptation period, while TEI graduates are mostly practice-wise trained. Therefore the latter adapt very easily, thus showing a very positive balance. Those findings are a reinforcing element related to the need of the broadening of the tertiary level technological education in Greece.

In compliance with the above remarks about the positive balance of supply-demand in T.E.I. informatics graduates, we state that: according to statistical data of the Greek Technologists Engineers Union. (G.T.M.U.), the Union members that are unemployed in the expertise area of Informatics Engineers and Computer Systems Engineers reaches to just 3.6%. That percentage rate is a lot lower, compared for example to that of Electronic Engineers (6.4%).

A more practical approach towards the evaluation of the needs, the potential and the tendencies of the Greek Information-Telecommunication market, has been conducted –for lack of official registered data- by studying various elements that arise from different sources. More specifically:

- From the Greek software developing companies; Statistical Company ICAP conducted a research for the business transactions of 44 software-developing companies. The results published (5), must be pointed out, since the increase of sales (turnover) between 1996 and 1997 has reached on the average the impressive rate of 52.1%.
- From the newspaper ads that represent one of the most significant employment finding; A published research (6) in Greek newspapers concerning the 1st quarter of 1998, has shown that companies use the newspaper ads mostly for hiring middle level executives, sometimes higher level as well. From the indexing of the material,

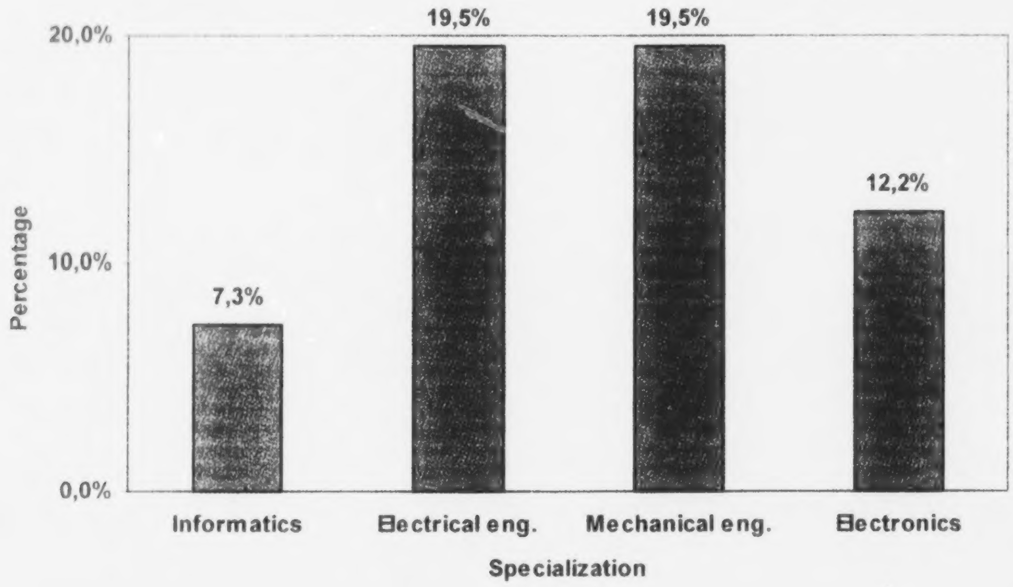
arises that the Informatics sector is included among the 10 sectors of the highest employment rate in Greece. More specifically, this sector is rated 5th, after some commerce sectors and tourism, all of them traditional powerful employment sectors for the Greek reality. Among the professions with the highest demand we have Telecommunications Engineers, Software Systems Engineers, Analysts-Programmers and Computers Technicians.

- From the Internet provider companies, a sector capable of employing a large number of employees, due to its fast development; Indicatives of that fast rise, are the transactions data of the FORTHNET company (7), the biggest company of that sector in Greece, according to which, the average rate of increase of new subscribers per month has reached the percentage of 10%. The total business transactions of this particular company have increased from 660 million GDRs (1US$=370GDRs) in 1996, up to about 5.5 billion GDRs in 2000.
- From the telecommunication companies; Their development in the Greek market is also very fast. Their business transaction is vast, a fact which actually leads to new employment needs, investments e.t.c. According to the data of the PANAFON company (8), its total business transaction has increased from 40.7 billion GDRs in 1995 up to 205.5 billion GDRs in 1998.

3. INFORMATICS SCIENCE STUDIES IN T.E.I. - COVERING THE DEMAND

Diagram 1 presents the percentage of four departments in Technological Application Schools of T.E.I. in Greece (9). It is obvious that the low rate of the Informatics Departments does not comply with the vast development in the sector.

Diagram 1. Department percentage in the country



Moreover, the increasing demand for professionals in informatics graduating from TEI, is also proved by the results of the research conducted by the Greek Ministry of Education in 1996, which was based on the candidates' computerized preference declaration cards for the tertiary level of education. On the grounds of the analysis of the demand for the positions announced in AEI and TEI, we conclude that informatics in TEI cover only 21.6% of the demand. This rate is the lowest among all the other ones concerning expertise areas in TEI reported in the research. On top of that, there is no significant modification of that percentage rate, up to this moment.

4. INFORMATICS SCIENCE IN CRETE: OBJECTIVES-SCIENTIFIC INSTITUTIONS

Concerning education in the field of informatics in Crete, a study of the national employment observatory (10), has proved that Crete absorbs 14,8% out of the available funds for the employment training in informatics issues, which is the 3rd largest percentage in the entire country. Moreover, the policy of the Regional Administration of Crete, which was announced in the 2nd Development Convention (11) of the Region of Crete in June 1998, set as its major goal the development of the island, so that the latter will constitute a kernel of telecommunications and telematics applications in the Northeastern Mediterranean and also of a innovative regional model of the IS. According to the conference proceedings, telecommunications and informatics constitute important joint-forces of economic development, social welfare, and competitiveness of the Cretan economy, while being in need of strategic and systematic effort for their implementation during the next decade.

In the region of Crete and in the scientific area of the sciences of Informatics and Telecommunications, there exist and operate several educational and research institutes: In Chania, the Electronics and Computer Engineering Department of the Technical University of Crete and the Electronics Department of the T.E.I. of Crete. In Iraklion, the Computer Science Department of the University of Crete and the Institute of Informatics of the Foundation of Research and Technology. On top of that, a new department has been recently added to the T.E.I. of Crete.

5. THE T.E.I. DEPARTMENT OF INFORMATICS IN CRETE

5.1 Perspectives-particularities

A new Department has been established in the T.E.I. of Crete in the field of Informatics, under the title "Applied Informatics and Multimedia". This Department combines applied informatics and tele-informatics, telecommunications and multimedia in the most effective way so that the students of the department are able to become familiar (during their studies) with the convergence of technologies which leads to the I.S. Consequently, the graduates will have integrated education, on the one hand, and he necessary specialization, on the other, in order to immediately cover the needs of the labor market.

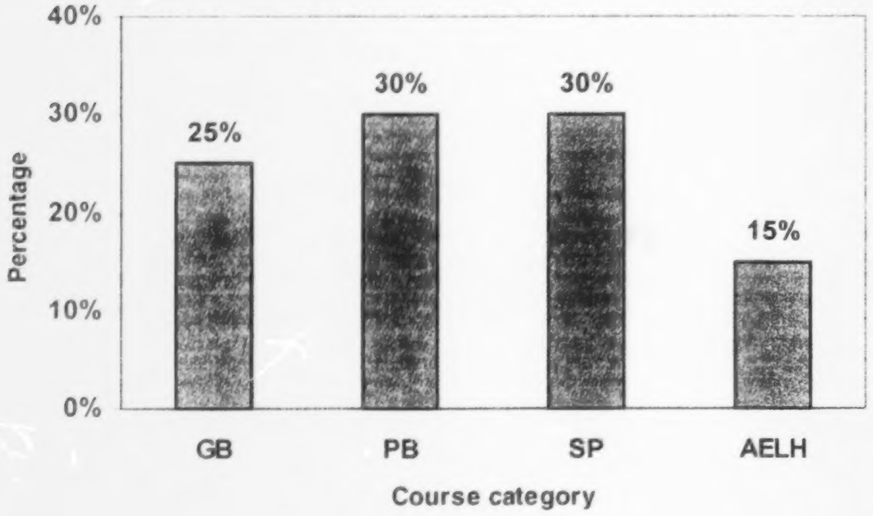
5.2 Structure of studies

The duration of studies is eight semesters in total, the first seven of which include course teaching while the eighth is devoted to practical training and the completion of a graduating project. Courses are divided into 4 major categories, according to the suggestions of the Institute of Technological Education of the Ministry of Education (12). More specifically, these categories are:

- General background (GB)
- Particular background (PB)
- Specialization (SP)
- Administration, economics, law and humanitarian studies (AELH)

Their percentage proportion is shown in diagram 2.

Diagram 2. Course percentage according to category



Additionally, the curriculum is organized in such a way that, students have to choose between two specializations (Informatics and Telecommunications-multimedia) out of a series of choices allow them a number of different combinations.

Taking into consideration that the department provides a common degree to all students, they are obliged to acquire core training in all major knowledge fields of the department.

6. Operation of the Department and Student statistics

The first 246 students were admitted in autumn 1999 after they had passed the national examinations set by the Hellenic Ministry of Education. Table 1 shows the number of admitted students along with those who enrolled and attended during the two years of operation of the Department. Having completed the first year of studies in the Department, about 85% of the initially enrolled students remain active. This percentage is very high compared with the analogous percentage of the traditional Departments and shows the big interest of students on the new courses.

TABLE 1: Number of total admitted, enrolled and students who attend for the two years operation of the Department

Academic Year	Admitted Students	Enrolled Students	Attended Students
1999-2000	246	226	192
2000-2001	321	296	293
Total	**567**	**522**	**485**

Besides being a new Department, a relatively great number of degree holders apply to the new Department with the intention of acquiring a second degree with effect in the labour market. Table 2 shows the number of applicants who graduated from other Departments AEI or TEI along with the selected and registered number for each Department for the two years of operation. The numbers show that many graduates from traditional AEI and TEI find it difficult to get a good post in the labour market, so they make an effort for a second degree with effect in the market.

TABLE 2: Number of AEI and TEI graduate applicants selected for a second degree from the Department

Academic Year	**1999-2000**		**2000-2001**	
Department of AEI	**Applications**	**Selections**	**Applications**	**Selections**
Physics	2	2	8	2
Mathematics	1	1	7	1
Chemistry	-	-	5	2
Biology	-	-	4	1
Teachers' Training	1	1	3	3
Computer Science	1	1	2	-
Others	1	1	8	7
Subtotal	**6**	**6**	**37**	**16**
Department of TEI				
Electrical Engineering	3	3	11	1
Mechanical Engineering	1	1	3	-
Civil Engineering	4	4	5	2
Others	8	7	19	3
Subtotal	**16**	**15**	**26**	**6**
Total	**22**	**21**	**63**	**22**

7. CONCLUSIONS

In this paper the results of the feasibility study for the new Department have been presented and analyzed and the process and philosophy of the new curriculum have been described. The proposed AITM department's curriculum in the TEI of Crete combines applied informatics, communications and multimedia in the most effective way so that the students of the Department are able to get familiar with the convergence of technologies, which leads to the I.S.

Also, the new courses support new features and ideas which: Keep student load within realistic limits and in accordance to other EU countries and practices, recognize the changing role of the lecturer to that of a " facilitator", i.e. moving away from " chalk and talk" practices, increase student choice and flexibility (wherever possible)

Furthermore, some statistical data of the operation of the new department were analyzed and reflections on its future and viability were outlined. It is pointed out that there is a great interest for the new department from the secondary education candidates as well as from graduates who want to acquire a second degree with effect in the labour market.

The assessment (13) that has been made by national and foreign external examiners reports among others, the following:

"*...Compared to other departments of not only TEI, but AEI as well, these data classify the department among the ones of high demand. Additionally, there is a relatively high percentage of AEI graduates that participated in the classification exams for registering to that department... In conclusion, it is a modern curriculum, of high level, which covers the needs of Greek economy and functions perfectly, offering big opportunities. It could have been a model for other curriculums of conventional or non-conventional 3rd degree education. I think it is one of the few programs of studies that could cover the basic costs of operation on their own, provided that there would be the proper legal adjustment*".

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Teachers' Ideas on Computers after Some Initial Information Technology (IT) Training

G. S. Ioannidis and D. M. Garyfallidou
gsioanni@upatras.gr, d.m.garyfallidou@upatras.gr
D. G. Vavougios, Univ. of Thessalia and Univ. of Patras, Greece
dvavoug@upatras.gr

Key words: *Teachers' Ideas, Computer education, Pedagogical issues, University Teaching, Information Technology Literacy*

ABSTRACT

Computer literacy is essential so as every serving teacher is able to handle the curriculum demands for using IT in classroom. All students graduating today from teacher-education university schools have (or should have) achieved computer literacy, to a greater or lesser extent. This still leaves the great bulk of schoolteachers serving today without proper training on computers. From a ***constructivist*** point of view, when faced with the task of teaching computer literacy level to serving teachers, our first aim should be to ***study their ideas*** about computers and the impact of their usage.

The present study focuses on the ideas held about computers by active primary schoolteachers. Some 164 teachers participated in the present study. These have been given a thirty-hour course on computers and their uses before their ideas have been examined. The teachers' experience (and their age) varied considerably and this factor is examined in the present study. The computer course contained various computer literacy issues including basic aspects about the structure and function of computers. Although the computer course contained various computer literacy issues, it was not judged by the authors as being a comprehensive "IT literacy" course.

Basic concepts like the teachers' ideas on the functioning of microprocessors the role of operating systems and the distinction between hardware and software are examined. These are related with their ideas on the socio-economic impact of the proliferation of computers and on artificial intelligence and its relation with various aspects of human cognition. Their ideas on educational software and its use were also examined and correlated with the above questions. Various interesting conclusions are drawn. The results are thought to have an impact in the current effort for the introduction of IT in all schools within the European Union, just starting.

1. Introduction

It is almost universally agreed today that every school leaver should be proficient in computers, having acquired the basic skills as well as knowledge about computers, which comprise what is generally called "computer literacy". There are various views on ***how*** this can be ***implemented*** [1]:

a) A school subject on basic computer literacy.

b) Hands-on experience on using information technology (IT), while avoiding the task of teaching the way this technology is achieved.

c) The incorporation of the use of computers in the teaching of different subjects, e.g. by using educational software for science, mathematics and other lessons (hoping that task "B" will occur naturally through the mere exposure of the student to IT).

It is rather obvious to a distant observer that, in choosing amongst the above three views, a lot of wishful thinking is called for, while the practical implementation of one of the methods has to seriously consider the various elements of everyday school practice (e.g. teacher proficiency in IT, school-space considerations, time-scheduling considerations, economic considerations e.t.a.). On the other hand, the three views (above) are not mutually incompatible; it could even be, that the aim should be to combine all three views in every school curriculum.

Let us consider the use of IT in education. Generally, it serves three distinct ***purposes*** [2]:

1. To get pupils to learn about IT: (a) How IT works. (b) How to use IT. (c) Socio-economic implications of proliferation of IT usage.
2. To support teaching and learning across the curriculum.
3. To aid the administration and management of the school.

It follows that while the second aim matches precisely with implementation method (C) for teaching, the first aim remains not so properly tackled by anything other that an independent fully fledged computer literacy course (e.g. implementation method (A) above). Purposes 1.a and 1.c, in particular, call for such a method for, it is hard to see how even a specialised "use IT" course (e.g. implementation method (B) above) could even endeavour to aspire to such analytical depths of knowledge as the ones specified. By drawing the distinction between utilitarian and epistemic instrumentality, would sharpen the distinction between learning and training. It would help to separate the acquisition of skills, i.e. patterns of action, from the active construction of viable conceptual networks, i.e. understanding [3].

No matter which implementation method is selected, (in practice often selected by default, unfortunately) there is a precondition for some or all of the schoolteachers: They should have acquired computer literacy, as it is self-evident. Not only should they just have acquired basic IT skills, they should also have achieved "computer literacy" in a true sense of the term. Such knowledge is essential for them to be able to handle the curriculum demands either for teaching IT or for using IT in the school-lab or the classroom.

2. The training problem

All students graduating today from teacher-education university schools have (or should have) achieved computer literacy, to a greater or lesser extent. These still leaves the great bulk of schoolteachers serving today without proper training on computers. As the need for a quick (and belated) introduction of primary-school children to computers becomes evident, (and increasingly imminent for the European Union countries) the need to re-train existing and serving primary schoolteachers to using computers in the classroom becomes crucial. It is obvious that what a student can learn is strictly dependent on what the teacher knows: his/her knowledge may be acquired partially in an autonomous way but the main channel to information is the teacher's communication. It is then important to investigate the status of teacher's knowledge also with the aim of defining possible obstacles to conceptual change [4]. Computer literacy for every serving schoolteacher is the aim. This becomes the key-issue in the effort to train young children to the tools of the new millennium.

3. The educational problem

Computer literacy is essential so as every serving teacher is able to handle the curriculum demands for using IT in classroom. Computers are a quasi-scientific subject [5] and yet they need to be explained in simple terms to teachers, most of which are arts-based in their way of thinking and their training. Most have little or no experience in either the scientific methodology or the scientific way of thinking. From a ***constructivist*** point of view, when faced with the task of teaching computer literacy at the appropriate (e.g. university) level to serving teachers, our first aim should be to ***study their ideas*** about computers and the impact of their usage.

Research on in-service teacher's ideas has proved that teacher's attitudes and beliefs influence their perception and understanding of classroom events and may, therefore, affect the classroom behaviour. It is also widely known that primary schoolteachers have cognitive inadequacies, themselves. Constructivism, on the other hand is not simply a statement about how children think, but it is rather a statement about the nature of thinking. Whatever characteristics we ascribe to children's thinking we should be willing to ascribe both to teacher's thinking and to our own thinking, as researchers [6].

4. The research

This study focuses on the ideas held about IT by active primary schoolteachers. About 120 teachers were used in the present study. These teachers' ideas have been examined after they have been given a thirty-hour introductory course on computers and their uses. This was considered necessary as for the overwhelming majority of them had no previous contact with IT whatsoever. Their ideas on IT would, therefore, be no different to those of any adult of the same age.

Although the computer course contained various computer literacy issues, it was not judged by the authors as being a comprehensive "IT literacy" course. The course contained various computer literacy issues including basic aspects about the structure and function of computers. The laboratory practice contained only the basic use of operating system and application software. The reason the whole course is judged to be of pre-literacy level were: (a) it contained no introduction to any high-level computer language, mainly due to (b) lack of teaching time, overall (30-hour including lab time per teacher). We agree strongly with the view that the understanding of "how computers think" is a most important aspect of any IT curriculum and that this can only be effectively achieved by incorporating an introduction to programming practices using a high level language, into the curriculum. The level attained was, nevertheless, appropriate for the present research to be carried out as, a 30-hour course is the most common length of time used for re-training purposes for schoolteachers at universities. The laboratory equipment used for (part of) the training was also typical. Overall, it was also considered that this pre-literacy course was at a level just appropriate for the following reasons. (a) The trainees would have reached their own verdict on what a computer does and its usefulness. Also, (b) the trainees not to have reached the point whereupon clear ideas on IT and its functions would have been formed (if the teaching was at all successful) through the process of rigorous teaching and exposure to computer programming through the use of a high-level language. The sum total of the teachers' prejudices and their difficulties in forming a self-consistent set of ideas about IT and its functioning (through the adaptation of their previously held ideas) would be revealed.

The teachers' experience (and their age) varied considerably. By the very nature of their grouping so that regular college-classes could be formed, they were divided into groups depending on their experience (e.g. years of services), which is directly related to the age:

Group A: serving schools teachers of younger age, roughly 33-43 age group. Sample N_A=38

Group B: serving schools teachers of middle age, roughly 44-50 age group. Sample N_B=37

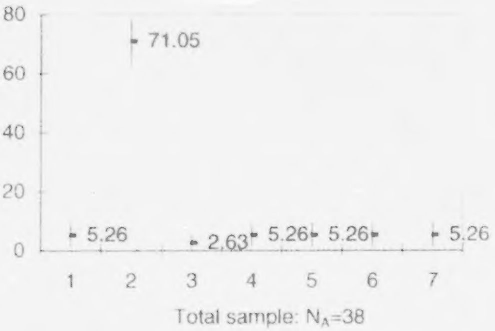
Group C: schools teachers with higher experience, mostly over 51. Sample N_C=89

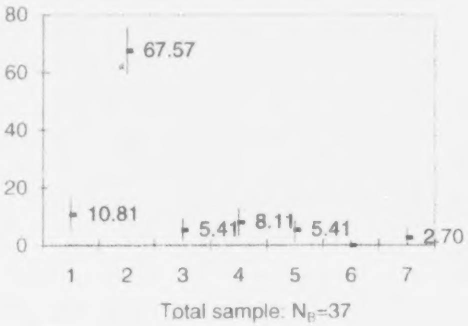
The training was done by a group of people and as mentioned before it included IT lab training which was always staffed by experienced instructors. At the end of each 30-hour training course a questionnaire tested their ideas and their knowledge on various IT aspects. All these aspects were examined at some depth during the course. Most, but no means all, of the teachers had no actual IT experience before the course. All the teachers decided to attend these courses on their own free will and although the retraining "package", as administered by the university, included many other subjects (from 9-27) they all knew that IT training will be included and some of them looked forward to it. It is, perhaps, important to note here that all teachers decided to attend not expecting that any direct financial or carrier advantage would be gained. They also attended at their own spare time. This on the one hand resulted in somehow tired trainees but, their motives could not be faulted and their perseverance could only be admired. We therefore believe that this (in many ways) incomplete IT training was given to teachers who really wanted to learn. At the same time, when the knowledge and their ideas were evaluated at the end of the course, these teachers were more inclined to express their own opinion as opposed to reproduce what was taught to them during the course. Quite a number of them were self-opinionated and quite stubborn, in fact. The questionnaire included, at any rate, redundant questions so as to check whether the answers were genuine expressing the teachers' opinion and whether they understood the meaning of their answer. It was not considered to be in anyway relevant to examine the teachers' ideas on IT matters before the course took place. These would not be in any way different to those of ordinary citizens of their age, few of which have any professional contact with IT.

The total sample of teachers was N= 164. Not all teachers were necessarily questioned as to their ideas on all concepts studied. All relevant statistics were calculated using specially constructed software, interfaced with a popular computational and plotting package. The statistical variance was computed and the Bessel-corrected standard deviation was calculated for all data points to be presented. No experimental measurement can avoid systematic errors. In the present study special care was taken (for reasons explained above) so that large systematic were avoided. We then went on to evaluate the systematic error remaining, and this was set at 1.5%, a figure considered to be fair (if on the low side) and which is consistently lower than almost all our statistical errors. This means that we believe our total error to be statistics dominated for every single data-point presented. The total error was then found by adding in quadrature our systematic with our statistical errors, these two being independent by definition.

The data are mostly presented in histograms, depicting the percentage of teachers holding a particular idea. The error bars on each point of the histogram represent one total standard deviation on either side of the point as computed for this single point. When the data are presented in tables, the standard deviation follows every measurement made.

4.1 The teachers' ideas on the function and role of microprocessors.





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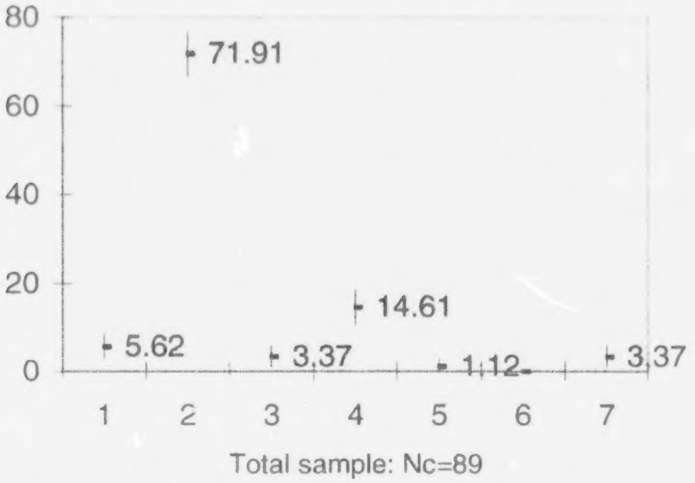


1. A small computer of limited capability for personal use.
2. A central processing unit (CPU) implemented on a single integrated circuit (chip)
3. An electronic unit of limited capability used as a component to construct computers up to 1965 or whereabouts
4. A program that can process data (numbers or characters) at high speed.
5. Answers (a) and (c) at the same time
6. None of the above
7. No answer given

Figures 1 A,B,C

All numbers represent percentages

In Figure 1, the teachers' idea on the functioning of microprocessors is depicted. The caption explains the categories in which the teachers' answers where set. As the error bars depict the one standard deviation, we can see that by a quite significant percentage the teachers seem to hold the right idea on the nature of microprocessor and its function. As the answers are dominated by selection 2 (see caption figure 1) no significant difference can be detected between samples A, B, and C, within our experimental limits.

4.2 The distinction between hardware and software.

The teachers were asked to describe what do they mean by the term software and hardware and to give one or more examples in software and hardware in IT. The answers were assessed as being good, average, mediocre and wrong whereas given the examples were assessed by the researchers by either correct or no. All combinations where observed regarding teachers' ability in defining what constitutes software (and hardware) with their ability to select a correct example to illustrate the idea of the concept. The answers where, therefore, combined into a two-dimensional table (table 1). The numbers represent percentages of teachers in this combined category. Each experimental point is followed by the total error associated with it and this is given in the darker background column next to the rate column. In two dimensional binning, the points in every bin fall, with the corresponding increase in the statistical error component. For this reason all available data (coming from all groups) are summed up. We observe that the teachers who were able to pick up a correct example (of either hardware or software), were also able to give a fair description of the relevant term using words. This perhaps points to the need of more examples to be presented to the trainees, especially of software.

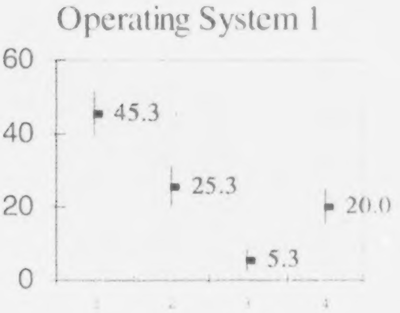
Hardware	Correct example		Wrong example		No example		Total	
Description	rate	error	rate	error	rate	error	rate	error
Good	21.3	4.8	0.0	1.5	3.8	2.6	25.0	5.1
Average	2.5	2.3	0.0	1.5	5.0	2.9	7.5	3.3
Mediocre	8.8	3.5	0.0	1.5	15.0	4.3	23.8	5.0
Wrong	0.0	1.5	1.3	2.0	15.0	4.3	16.3	4.4
No answer	0.0	1.5	0.0	1.5	27.5	5.2	27.5	5.2
Total	32.5	5.5	1.3	2.0	66.3	5.5		

Software	Correct example		Wrong example		No example		Total	
description	rate	error	rate	error	rate	error	rate	error
Good	10.0	18.1	0.0	1.5	8.8	3.5	18.8	4.6
Average	5.0	2.9	0.0	1.5	12.5	4.0	17.5	4.5
Mediocre	5.0	2.9	0.0	1.5	15.0	4.3	20.0	4.7
Wrong	0.0	1.5	1.3	2.0	16.3	4.4	17.5	4.5
No answer	0.0	1.5	0.0	1.5	26.3	5.2	26.3	5.2
Total	20.0	4.7	1.3	2.0	78.8	4.8		

Table 1.

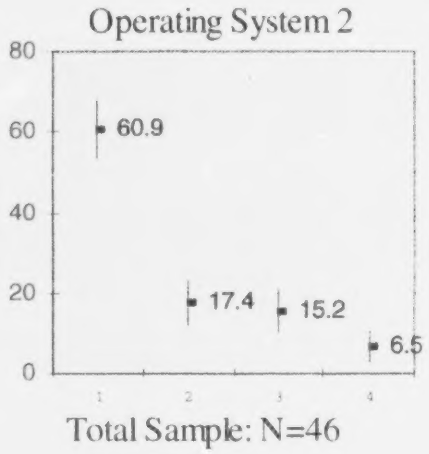
Comparing the data for hardware and software we observe that while the number of teachers having a scant idea of any of the two concepts is roughly the same (within errors), the rest show a significant difference. A much high percentage of teachers are able to give a reasonable description of what they mean by hardware and give an example, whereas their idea about software is much more vague and a significant number cannot offer any example of any software. This was expected: software as a concept is much harder to convey and to understand.

4.3 The role of operating systems.

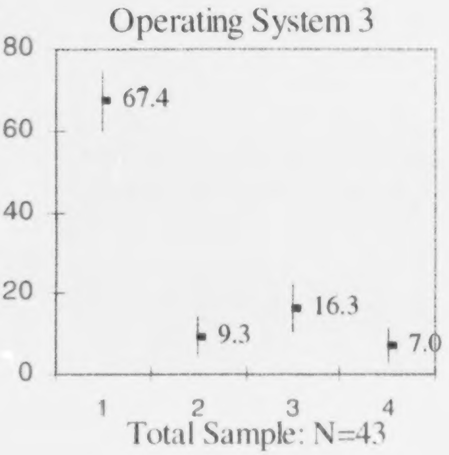


Total sample: N=75

1. Correct answer
2. Confusion concerning the dinstinguishing amongst the funcions of the O.S and those of the application programs
3. Vaque idea on services offered by O.S.
4. Hold the idea that the O.S. interfaces hardware components
5. no answer



1. Correct
2. 2. Hold the idea that the O.S. interfaces the computer peripherals with parts of the CPU.
3. Failure to conceive the O.S. as made-up from many system programs.
4. No answer



1. Correct
2. The job scheduling task of the O.S is seeing as its' only function while the real-time and multi-tasking features are not understood
3. Confusion over the functions of application programs and those of the O.S.
4. no answer

Figure 2 (approach 1,2,3)

We collected data for teachers' ideas on the operating system using three different approaches. The data collected are depicted in figure 2.1, 2.2 and 2.3. Each figure corresponds to teachers of all 4 groups (A, B, C) but not every teacher was asked to answer every question. The captions to the right each figure correspond to the teachers' answers relating to their ideas. In each figure the first point correspond to the orthodox point of view and the others follow in decreasing order of relevance. The first figure 2.1 answers to the question of what an O.S. is. Figure 2.2 relates to the interfacing function of the O.S. and it examines the ideas the teachers hold on what parts of the computer system are interfaced by the OS. The third figure shows what the teachers think an O.S. does or can do.

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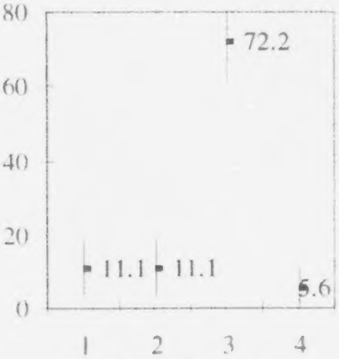
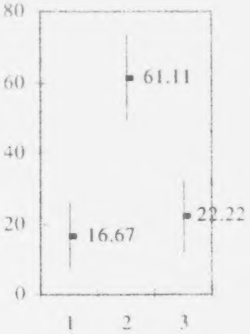
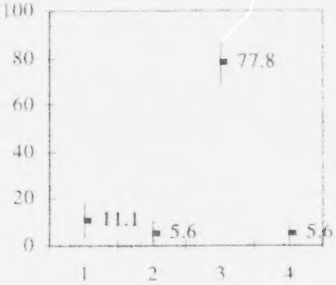
4.4 Teachers' ideas on the socio-economic impact of the proliferation of computers



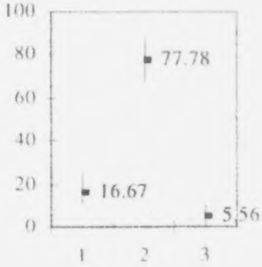
Total Sample: N=18
Figure **3.A.1**



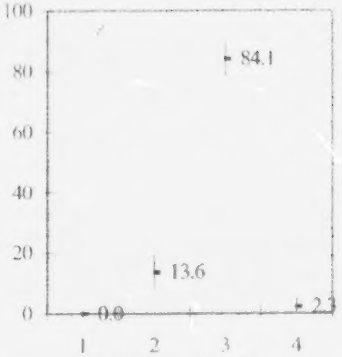
Total Sample: N=18
Figure **3.A.2**



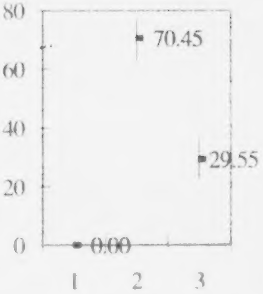
Total Sample: N=18
Figure **3.B.1**



Total Sample: N=18
Figure **3.B.2**



Total Sample: N=44
Figure **3.C.1**



Total Sample: N=44
Figure **3.C.2**

Caption corresponding to 3.A.1, 3.B.1 and 3.C.1

1.1 Will create increasing problems of mass unemployment in almost all professions

1.2 Will create problems in only some professions, whereas others (e.g. teachers) will not be replaced and could even benefit from it.

1.3 Opinion 1.2, and in addition many new job opportunities will be created in some new specialised fields

1.4 No answer given

* * * * * * * *

Caption corresponding to 3.A.2, 3.B.2 and 3.C.2

2.1 Will alienate humans thereby creating an inhuman civilisation centred on machines

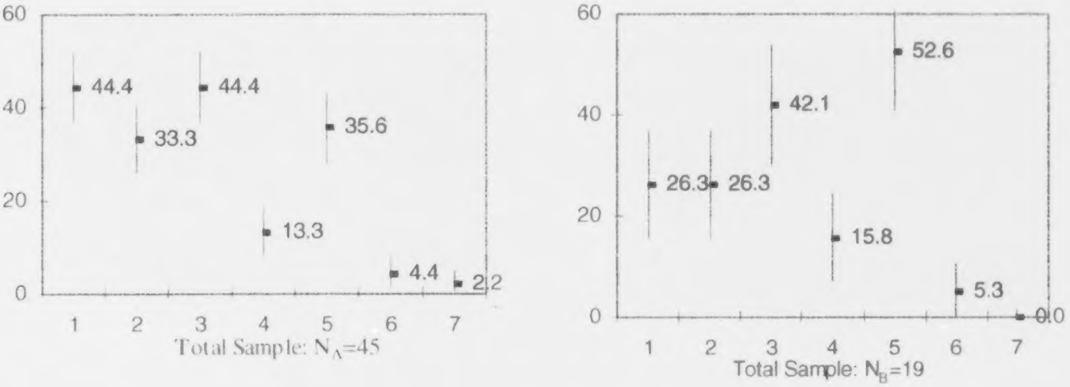
2.2 Will increase the communication amongst people due to increased communication capabilities and more spare time for leisure

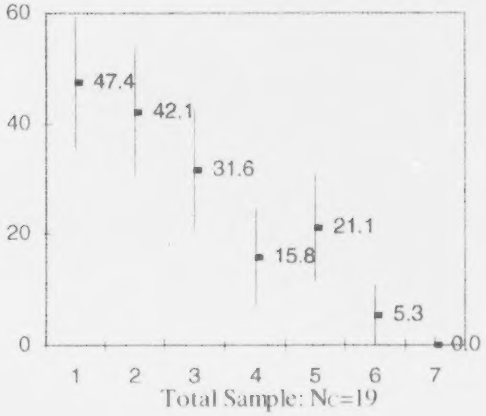
2.3 No answer given

Their opinion on future impact of IT proliferation was investigated basically along two different lines: employment and communication. The data collected were processed unrepentantly for each of the two lines and are presented separately for each group, despite the fact that the total number of teachers examined is relatively small. Figure 3.A.1, to 3.C.1 shows the data collected and the relevant errors. Regarding employment, we detect a small but definite trend for our more mature teachers to be more optimistic. Could this be because they considered their jobs very secure? Or their retirements already close enough? Another explanation could be that the more experienced teachers were more genuinely interested to learn having higher order motivation.

All teachers thought highly both of the communication aspects offered and of the increase of productivity offered by the use of IT. A sign of progress here.

4.5 Teachers' ideas on artificial intelligence and its relation with various aspects of human cognition.





1. Intelligence is an exclusively human quality and there is no sense to talk about intelligence in a soulless contraption, like computers are
2. Computers are in a sense like a large and fast calculator from which "human" properties like creativity and sentiment are lacking. The computers would therefore never be able to substitute man.
3. Computers would always be dependent on man's will, because they are his creations.
4. Computers were developed from calculators (without being such) but at the same time computer programs are not constrained to develop creativity on their own free will.
5. Answer d, and in addition there already exist some programs which can create works of art, write their own poems and take decisions while playing chess (for example) They can even improve upon themselves by learning from their own mistakes, which in itself is a learning process.
6. None of the above
7. No answer given.

Figure 4 A,B,C

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In this part of the study we probed the teachers' believes on intelligence as being an exclusively human quality and computers' ability to develop artificial intelligence and also perhaps learn from their own mistakes. Concepts like soul, creativity and sentiment were used to test how easily could the teachers dissociate from these being exclusively human properties, and very important ones for that. The data were processed so as the teachers were able to select whether they agreed or not with one or more from a number of points of view, described in the caption of figures 4. These figures depict the choices of the teachers, groups A-C concerning the points of view tested. Please note that as the teachers could select more than one answer as being a fair description of their opinion, the percentages in each figure do not add up to 100. As we progress from answers 1-6 the opinions change in that order from very traditional to modernist beliefs. It is therefore possible to even attempt to draw a continuous curve amongst to these points. A surprising aspect of these figures is that the data collected from our younger teacher sample (group A) show a tendency to fall as we move to points of view that are more modern. This could indicate that younger teachers hold more traditional points of view than other groups or perhaps that this is a more general trend amongst all teachers and that our IT-training course only attracted the teachers from the older age groups B and C who were more open-minted about technology. If this is correct, it could only mean that teachers (more or less) expected implicitly for IT to be taught extensively during their retraining, thereby discouraging those of them who were more traditionally inclined to addend. (Many different lessons were also taught during retraining).

Taking these figures overall, we can deduce that traditional beliefs concerning intelligence and creativity as being exclusively human traits still hold fast. A more hands-on didactic approach is called for, perhaps. The laboratory use of a software package with a high AI content could be very valuable to transforming teachers' (and students') opinion.

4.6 Teachers' ideas on educational software and its use.

The teachers were asked to give their opinion and describe what (they think) constitutes educational software. They were also asked to give examples illustrating their opinion and provide explanatory support of their point of view as to why what they describe really is educational software. During the 30 hour course this subject has been examined and some examples were also exhibited in the laboratory. Te teachers' response shows that quite a lot of them simple fudged the question giving a much too general answer, although quite a lot of them did give it a try. As all answers were descriptive, the use of a systemic network was necessary so as to categorise teachers opinions and beliefs. As a definition of the categories of application software that could be used in education, we used the categorisation already published by some of the present authors [7],[8]. Three categories of software used in education were defined:

a) Programs lucking educational target, per se: Word processors, spreadsheets and programs for statistics, data base management systems (DBMS), encyclopedias, dictionaries, geographical atlases, thesauri, information processing,

b) Presentation software, including any type of authoring tool. This software does not have specific education content but with some additions by "authors" it can acquire some. Limited in flexibility, scope, and presentation potential, this category creates "electronic books" (sometimes glorified) and forms the middle category leading to fully-fledged educational software.

c) Educational software: Drill and practice, tutorials, educational programs and educational games, simulators. All written using high-level languages, quite often of the object-oriented variety.

In addition to these distinct categories, for the purpose of the present analysis some further categories were defined to categorise teachers' opinion (see table 2). These were grouped as "abs", implying the collective use of all the three software categories (defined above) and, also, a distinct "general" category, which contained all opinions that were vague enough to be judged as fudged. Some answers were specific but where judged "wrong" and this forms its own category. The teachers' ideas are grouped in a two dimensional table 2. (As previously, the standard deviation figures follow those of the rate (expressed as a percentage) and are set in columns with a dark background.

From the comparison of the two tables, we can observe that the more experienced teachers seem to have reached a point whereupon they distinguish the existence of specialised educational software. At the same time, another set of teachers from this group exhibits a lack of understanding of what constitutes educational software, by holding a wrong opinion.

This group is therefore more polarised than the less experienced group. When the mass media prevail confusion reigns and that could offer a possible explanation of this effect. When the teachers were asked to mention examples of relevant software that they know of, a full set of examples were collected (from those who bothered to offer an

Ideas of the constitutes "educational software"	Justification for the ideas held about what constitutes educational software									
	Correct		General		Wrong		No		Total	
	rate	error	rate	error	rate	error	rate	error	rate	error
a	0.0	1.5	2.6	3.0	2.6	3.0	0.0	1.5	5.3	4.0
b	2.6	3.0	0.0	1.5	0.0	1.5	0.0	1.5	2.6	3.0
c	0.0	1.5	0.0	1.5	2.6	3.0	0.0	1.5	2.6	3.0
abc	7.9	4.7	2.6	3.0	5.3	4.0	0.0	1.5	15.8	6.2
general	7.9	4.7	10.5	5.3	21.1	6.9	0.0	1.5	39.5	8.2
wrong	0.0	1.5	0.0	1.5	15.8	6.2	2.6	3.0	18.4	6.5
no answer	0.0	1.5	0.0	1.5	0.0	1.5	15.8	6.2	15.8	6.2
total	18.4	6.5	15.8	6.2	47.4	8.3	18.4	6.5	Total Na=38	

Table 2A Group A

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		Justification for the ideas held about what constitutes educational software									
		Correct		General		Wrong		No		Total	
		rate	error	rate	error	rate	error	rate	error	rate	error
Ideas of the constitutes "educational software"	a	0.0	1.5	0.0	1.5	2.1	2.6	0.0	1.5	2.1	2.6
	b	0.0	1.5	2.1	2.6	0.0	1.5	0.0	1.5	2.1	2.6
	c	4.3	3.3	4.3	3.3	2.1	2.6	0.0	1.5	10.6	4.8
	abc	8.5	4.4	2.1	2.6	0.0	1.5	0.0	1.5	10.6	4.8
	general	6.4	3.9	10.6	4.8	6.4	3.9	12.8	5.1	36.2	7.2
	wrong	0.0	1.5	2.1	2.6	14.9	5.5	8.5	4.4	25.5	6.6
	no answer	0.0	1.5	0.0	1.5	0.0	1.5	12.8	5.1	12.8	5.1
	total	19.1	6.0	21.3	6.2	25.5	6.6	34	7.1	Total Nc=47	
		Table 2.C								Group C	

opinion). Judging from the overall shape of the data from our total sample, we cannot help but conclude that data are mostly disappointing and that teachers are confused on what constitutes educational software. The obvious moral is that more examples should be given and more attention paid to the subject if we could stand a chance of having any success in increasing the use of IT in classroom.

5. Discussion and conclusions.

The task of searching for teachers' ideas on IT is a complex one and we do not pretend that the present study is exhaustive, let along definitive. Certain results can be gained from it, nevertheless.

A first by-product of the present investigation has to be the one relating to the treatment of all data collected. Even with sample sizes like the present (by no means negligible for a science education study), if all errors (statistical and systematic) are taken into account properly, one becomes (as he should be) very cautious in trying to draw any conclusions from scant evidence. The effect becomes more noticeable when one tries to correlate different aspects of the data analysed, as in the two-dimensional tables, for example. Even with small systematics, as one tries to get more depth in his analysis, the numbers fall, the statistical error rise and therefore any evidence vanishes. The authors were by no means unaware of the effect; they simply draw attention to this fact, to serve as a reminder to those who confuse wishful thinking with true scientific methodology.

The good news is that some of the very basic concepts concerning IT can be given to teachers during a 30 hour course even to those who have been subjected to the vast misinformation onslaught of the mass media. Some more advanced concepts seem to be harder to grasp, something expected, obviously. No study has yet been made attempting to compare the ideas of younger university students (teachers-to-be) with the ideas of serving teachers and this is perhaps the next step.

Another conclusion from the present study seems to us to be that it is possible to teach computers to serving schoolteachers even if this is done after hours in their spare time. This result is comforting, especially in the face of the latest EU attempt to introduce each and every serving teacher into IT in record time, utilising the teachers' spare time. It would seem thought, that 30 hours is not a long enough period to attempt such a task. It may be that teachers are more tired and less adaptable to new ideas and concepts. On the face of the present evidence though, this does not seem to be the main problem. Pupils' attitude seems to be a far larger factor: those who come ready to be converted are converted and get onto the IT wagon. It would seem that all this talk about IT has convinced people that it is a net benefit for them to be using it as it both increases their communication capabilities and their effectiveness. In some other IT concepts (e.g. AI), teachers' ideas continue to be highly conservative. Previously-held IT information (or misinformation) is of not much help here, as it contains quite a high amount of imprecise or even wrong ideas; this is in no way different thought to what we encounter with undergraduate students. Serving teachers are in no greater disadvantage here. On the face of it, it would seem that more time is needed if a comfortable IT preliteracy level is to be reached. This is especially true for laboratory sessions and most of the teacher-trainees held this opinion too. More lecture time is also necessary to cover even the basic parts of the IT curriculum. Further training time seems to be necessary if true IT literacy is to be reached, as (a) this necessitates a minimum of an introduction to procedural programming to be included in the curriculum and (b) further exposure to more advanced IT concepts, necessary to effect the desired conceptual change to pupils' ideas on many of the simpler and basic everyday IT concepts.

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New Technology-based Reconstruction of Students' Ideas about Force

L. Papatsimpa, P. Dimitriadis, D. Imvrioti, A. Pavlou, S. Thomadaki,
M. Skalohoritis, and G. Kalkanis
University of Athens, Greece,
gkalkan@cc.uoa.gr

INTRODUCTION

According to a wide range of literature references , students perceive the concept of force quite differently from scientists. They develop an alternative way to interpret natural phenomena2. However, these alternative ideas about force are proved to be a major obstacle regarding adoption of scientifically accepted concepts. Traditional instruction does not seem to familiarize students with the scientific model of force, as it fails to confront their preconceptions, which derive from segmental and intuitive experience. Furthermore, experience originating exclusively from hands-on activities turned out to be insufficient as far as reconstruction of students' ideas is concerned. Students incorporate any new piece of knowledge into their preexistent mental frameworks instead of constructing new ones. As a consequence, the desired conceptual change of students' conceptions that will bring about the shift of students' ideas towards the scientific ones is considered to be an outstanding problem.

A solution may arise from a combination of laboratory and hands-on experience with appropriate educational software. Within such an environment students are supported to develop the ability of abstract thinking, which the comprehension of the scientific representation of force demands. With a view to provide the above mentioned environment we planned and developed educational software based on a curriculum proposal for the didactical approach of force – in Newton's Mechanics – addressed to Greek students of Primary School (grade 5).

The problem of Conceptual Change

According to Piaget theory children up to 9 years old (concrete operational stage) seem to believe that moving objects contain a force, which acts like an internal motor. By the end of this stage they consider force as the cause of movement that occurs independently and may even act on an object without moving it. At the next stage of cognitive development (formal operational) students accept that gravity accelerate objects as they fall down. The latter seems to be quite near the Newtonian concept of force (force = mass x acceleration).

Further research on children's, novices' and adults' ideas about force reveals four predominant conceptual frameworks:

a. Every movement presupposes force acting at the same direction.

b. The force acting on an object is proportional with the velocity.

c. No forces act on an object at rest.

d. An object moves towards the same direction of the force acting on it.

According to more recent research the concept of force as an entity included in motion not only doesn't fade after the age of 10, as Piaget supported, but is present in adults as well. The difficulty raising while students try to understand abstract scientific concepts, does not seem to be related with cognitive development stages as strongly as with the insufficiency of the didactical approach. The failure of traditional instruction to familiarize students with the scientific concept of force may occur, according to McCloshey, due to the fact that students develop an intuitive concept about force, which derives from everyday experience and is incorporated in an integrated theory about motion. However, diSessa supports that novices do not treat any case of motion in the same way, and as a result no integrated motion theory probably exists. Vosniadou and Brewer support that there is a greater extent of systemization at students' alternative ideas, attributed to a limited number of presuppositions that students form based on their everyday experience. There are seven mental models about force detected by research at Greek 10 to 11-years old students. The confusion between force and inertia appears to be dominant in all of them. In addition, in the vast majority of these models force is concurred with gravity, while regarding motion students seem to confuse force (cause) with motion (result).

The proposed didactical approach

Novices' alternative ideas about force seem to be based on a specific presupposition.10,12 Namely, every object has a number of properties related with natural phenomena; force is one of these properties. A didactical approach that aims at conceptual change regarding force should encounter the above mentioned presupposition. We believe that student should primarily be familiarized with the use of expressions like "a force is exerted on the object" when describing motion or equilibrium situations as a first step towards conceptual change. The traditional introduction to force exclusively through "push and pull" situations involving living bodies may reinforce alternative ideas.

According to our approach, students should consider force as a concept used for the description of phenomena related with changes of motion or shape. Furthermore they should deal with several types of force that may be exerted in contact or from distance.

Using these as guidelines we designed and have started implementing a curriculum and didactical material about force for students of Greek primary school (grade 5). The proposed didactical approach is based on multimedia software and includes simple modeling. Students follow instructions presetned electronic worksheets in order to perform simple experiments and study simulations on the PC screen. The simulations emphasize the distinction between the physical system and the model.13,14

Curriculum Design

The proposed didactical approach is estimated to last five hours of forty five minutes each and consists of three units: the concept of force, types of force and force in case of equilibrium. The aims as well as the duration of each one of the units is presented below:

The concept of Force (90 min)

Students are expected:

- to describe phenomena related with motion changes (start or stop) of an object using the concept of force (cases of equilibrium are not mentioned here)
- to describe phenomena related with changes of an object's shape by means using the concept of force
- to use the model of point mass and representation of force as a vector
- to identify and describe by means of force everyday phenomena

Types of Force (90 min)

Students are expected:

- to detect the object that causes changes (exerts a force) to another object
- to realize that there are forces exerted in contact or from a distance
- to deal with electric, magnetic and gravitational force as exerting from a distance
- to be familiarized with terms and expressions like "force", "exerts", "in contact", "from a distance"

Forces and Equilibrium (45 min)

Students are expected:

- to realize that even if there are forces exerted on an object there may not be observable changes.
- to realize that even if objects are in equilibrium state, forces may act on them (resultant force)
- to identify the forces acting on objects in equilibrium in everyday cases.

The educational software

The multimedia educational software has been developed in Visual Basic. It provides teacher (during the instruction) and student (at consolidation time) with a great variety of images, video clips and sounds as well as the facility to browse selected websites. The software has been developed in a twofold manner and includes two basic parts:

- Teacher's Part

Electronic worksheets of a multimedia character are included in this part for teacher's benefit during the lesson [Figure 1].

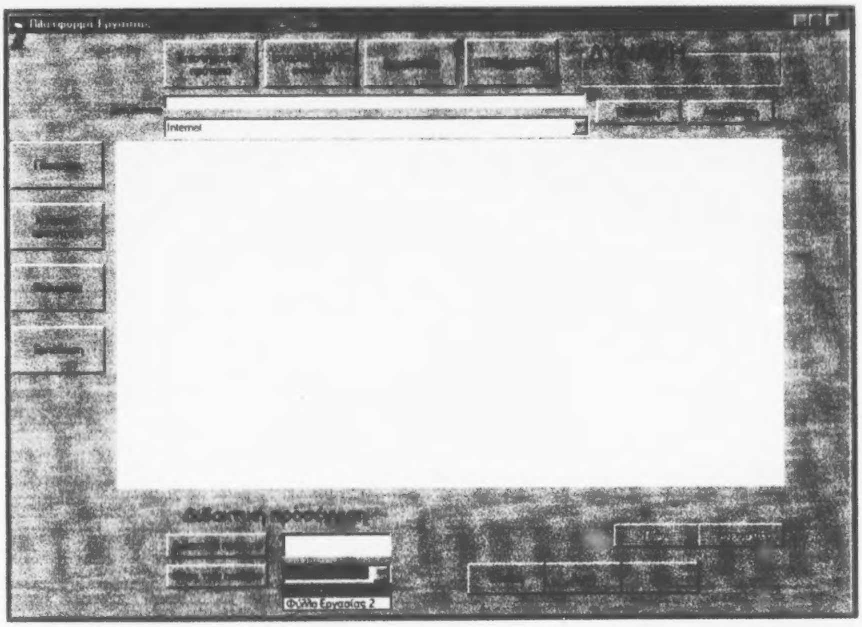
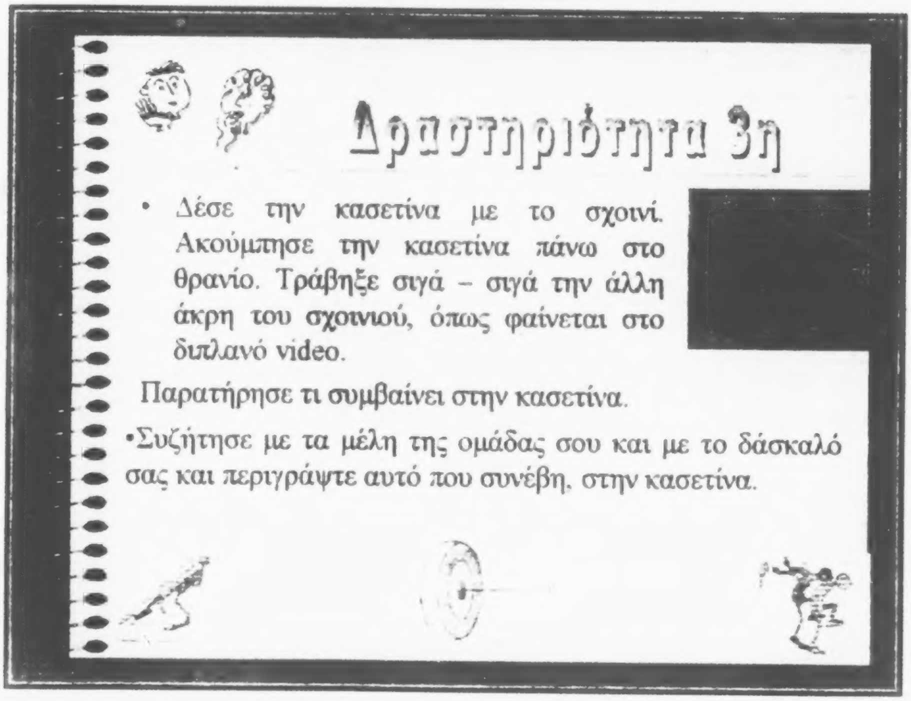


Figure 1. Central Platform of the Software



Δραστηριότητα 3η

- Δέσε την κασετίνα με το σχοινί. Ακούμπησε την κασετίνα πάνω στο θρανίο. Τράβηξε σιγά – σιγά την άλλη άκρη του σχοινιού, όπως φαίνεται στο διπλανό video.

Παρατήρησε τι συμβαίνει στην κασετίνα.

•Συζήτησε με τα μέλη της ομάδας σου και με το δάσκαλό σας και περιγράψτε αυτό που συνέβη, στην κασετίνα.

Figure 2. Electronic Worksheet - Experiment Instructions

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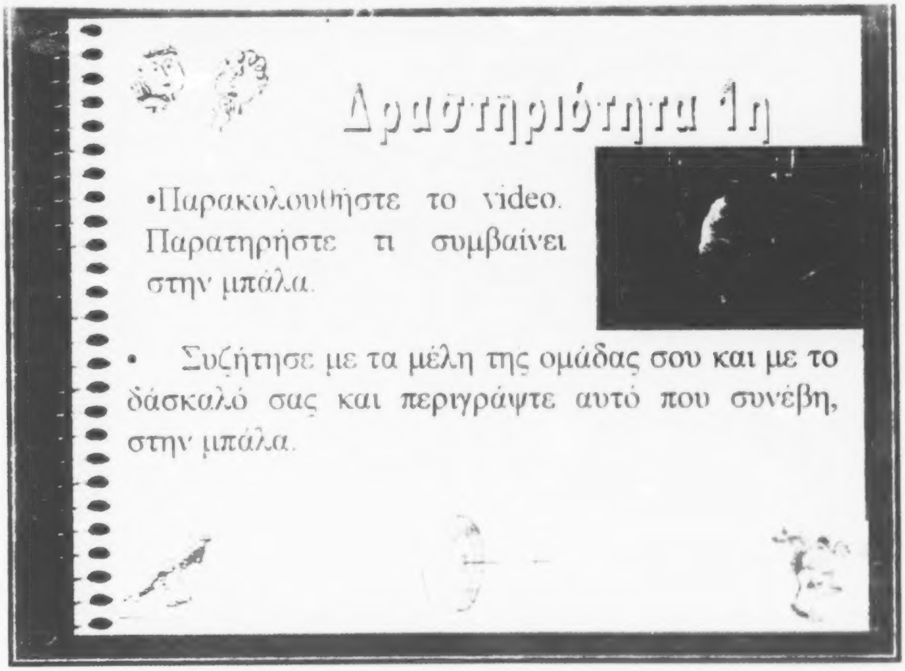
The worksheets along with written instructions contain video clips that present the experiments [Figure 2], focus on specific details of them (by zoom or slow motion techniques [Figure 3]) and combine the real world that students approach by their senses with the scientific model of it (by overlapping layers [Figure 4]).

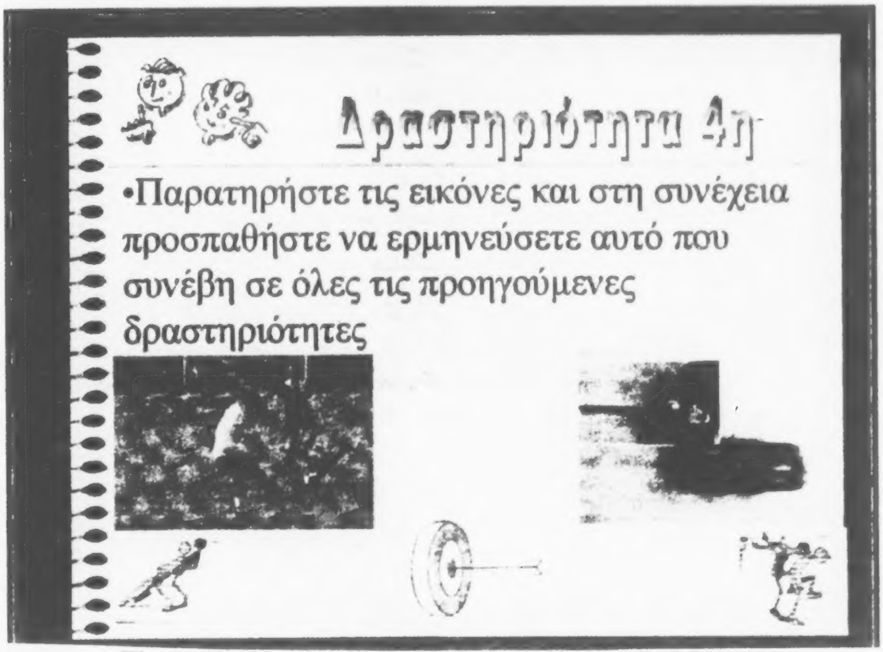


Δραστηριότητα 1η

•Παρακολουθήστε το video. Παρατηρήστε τι συμβαίνει στην μπάλα.

- Συζήτησε με τα μέλη της ομάδας σου και με το δάσκαλό σας και περιγράψτε αυτό που συνέβη, στην μπάλα.

Figure 3. Electronic Worksheet – Slow Motion Video



Δραστηριότητα 4η

•Παρατηρήστε τις εικόνες και στη συνέχεια προσπαθήστε να ερμηνεύσετε αυτό που συνέβη σε όλες τις προηγούμενες δραστηριότητες

Figure 4. Electronic Worksheet – Scientific Model

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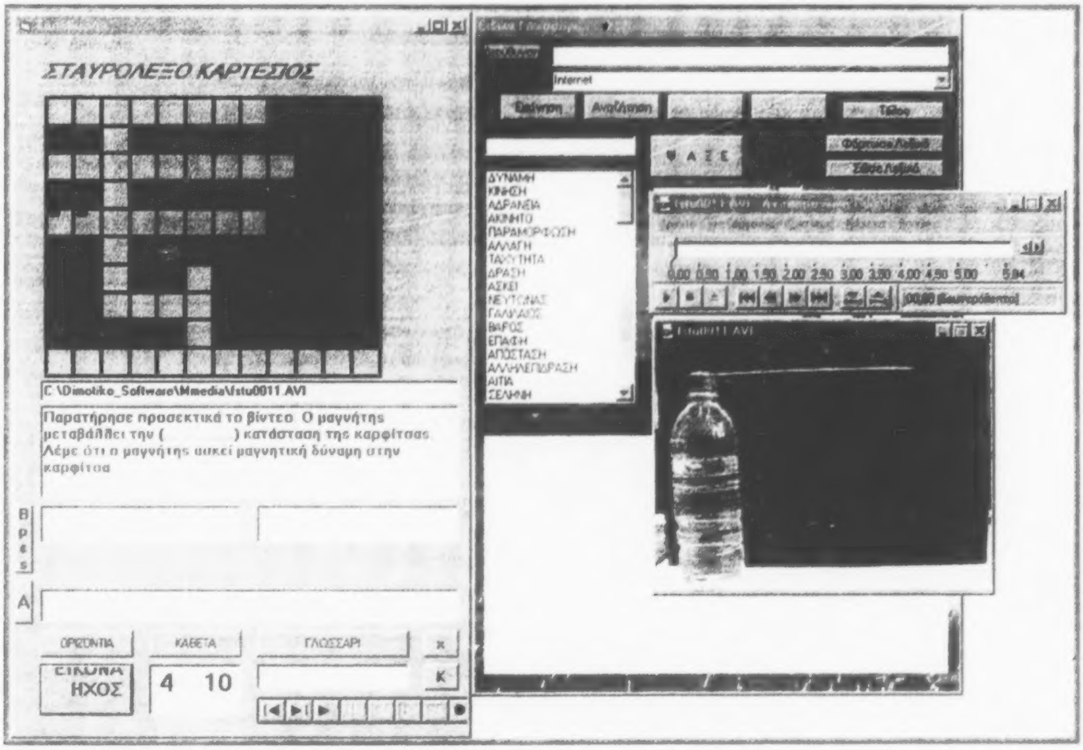
We expect that students will be enabled to realize that the central point of the scientific method is the development of models that describe physical systems. Interaction with the software is not provided, as we believe that the focus should be put on the approach of modeling process and scientific method by the students. As a result, the software leads - through analysis of empirical data and identification of the basic elements involved in each phenomenon - towards the scientific model. The didactical approach that is proposed by the software leaves space for Socratic dialogues by means of which students' abstract thought is enhanced and familiarization with scientific terminology is succeeded.

- Student's Part

This part of the software is designed to provide students with revision and consolidation activities. The latter include crosswords and puzzles. In each activity the student is asked to apply the scientific model in a certain physical phenomenon, which is presented by a video clip, an image or a sound [figure 5].


ΣΤΑΥΡΟΛΕΞΟ ΚΑΡΤΕΣΙΟΣ
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Παρατήρησε προσεκτικά το βίντεο. Ο μαγνήτης μεταβάλλει την (   ) κατάσταση της καρφίτσας. Λέμε ότι ο μαγνήτης ασκεί μαγνητική δύναμη στην καρφίτσα

Figure 5. Multimedia Crossword

We expect that the multiple approach of a physical phenomenon (by hands-on activities, pictures, video clips and modeling) will provide an appropriate field for the conceptual change to take place regarding the concept of force

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Scientific and Technological Literacy within Initial Training and Professional Development for Primary Teachers: New Opportunities for Global Outreach and Development Through TechnoScience 2000+

Eric Parkinson, Canterbury Christ Church University College, UK
efp1@cant.ac.uk

Keywords: Open/distance learning, Teacher training, Professional development, Curriculum development, Internet

ABSTRACT

The notion of "scientific and technological literacy" is an important one. Science and Technology will be increasingly called upon in the future to assist in finding solutions to global problems. There is a need for example to develop a fresh awareness of human actions and environmental consequences and to take responsibility for what has been done.

To achieve the rapid advances in scientific and technological education so urgently required, demands massive investment in the professional development of the current teaching force. In-service education however is expensive, especially when it involves taking teachers out of classrooms for significant periods of time.

Solutions to this problem are available. Opportunities for widening participation in pre-service and in-service measures for primary teachers are increasing all the time due to the influence of the Internet.

On-line learning and distributed learning are both providing avenues for access to forms of training that would have been impossible ten years ago.

The flexible learning materials of TechnoScience 2000+ have been designed to provide an open/ distance learning resource that can be used by individuals such as primary teachers and organisations as part of a programme to assist in finding solutions to in-service problems. The materials are Internet-based and specially created to extend teacher background knowledge and understanding of science and technology processes, together with consideration of societal implications. They also provide examples of related experiences for children.

This paper explores the role of TechnoScience2000+ as a change agent within science and technology education. Dissemination is of key importance here, and recent developments in global outreach that serve to widen participation in science and technology education are reported. So too are some of the possibilities arising from the use of transferable hypertext structures as templates for further Internet-based learning products.

INTRODUCTION

It is widely recognised that the study of science and technology is not conducted merely for its vocational value. Although doubtless that is important, it is increasingly clear that science and technology are of fundamental value in terms of their contribution to a broad, balanced and relevant education. The importance of the need to educate people to appreciate the processes and implications of scientific and technological activity rather than simply making things that "work" has become an important aim of educationalists world-wide. Increasingly this has become a concern of modern industry and it is thus entirely appropriate that the development of TechnoScience2000+ has been closely associated with a major industrial sponsor, the ICI Group.

The demands for change in many current patterns of science and technology delivery in education are urgent and insistent (Yager, 1996; Bybee, 1993) and increasingly underpinned by support documentation (Holbrook & Rannikmäe, 1997; ICASE, SEAMEO-RECSAM,UNESCO, 2001; UNESCO, 1999). TechnoScience 2000+ is a developing response to this cry for change. TechnoScience 2000+ has been founded upon open/ distance learning (ODL) materials constructed in order to assist primary teachers develop their own personal knowledge and understanding of science and technology issues. It is a measure to extend scientific and technological literacy (STL).The resource however is not a static, paper-based body of text and illustrations, but an organic mass of information available through the outreach possibilities of the Internet.

The Internet: an instrument for the spreading of knowledge and expertise for all.

Whilst Science and technology education may demand attention from educators in particular and society in general, the Internet likewise makes similar demands. It is rapidly becoming the universal organ for communication and knowledge–sharing. Since TechnoScience2000+ is a forward-looking resource that will develop and change in years to come, it is entirely appropriate that it should reside in an electronic format having the potential to be summoned from virtually any location on Earth.

Of course, from the perspective of electronic dissemination there are drawbacks. Telephone lines do not cover the globe. Electricity supplies can be unreliable or expensive to bring to remote areas. Computers are relatively expensive and require substantial memories to hold the bodies of software central to the management of electronic information. Typically, storage capacity is achieved through vulnerable hard disk drives.

These are power-hungry and sensitive to robust handling.

This paper asserts that none of these drawbacks will limit the eventual outreach of the TechnoScience2000+ resource. Today the cybercafe reaches out into developing communities and enables those who cannot own computers to gain access to the Internet. For the future, significant changes will broaden access even further. Radio communication is currently transforming telephone networks. The absence of a wired network is no longer a reason to deny access connection to the Internet. Erratic and unreliable electricity supplies from poor generating facilities will not limit computers equipped with a fold-out array of photovoltaic cells. Even the concept of a computer as an expensive electronic gadget may shift in the light of "broadband" high-capacity data transfer (Webb & Graham-Rowe, 2000). This may enable future computers to become simple platforms that download whole software packages from the Internet in order to process data. Such a system would mean that the latest software would be available to users, and even the storage of "local" data, currently stored on hard drives, could be independent of the computer itself. All of these factors point clearly to the future of personal information and communications technology. It will have the capacity to be simple, cheap and universally available.

Curriculum development and professional development

The 1960's, 70's and 80s'were times of significant curriculum and professional development initiatives in the UK. The domain of science and technology education was especially well-represented in this dynamic period (Nuffield Foundation Science Teaching Project, 1967; ASE, 1988; Black & Harrison 1985) . Reflecting and analysing this hot-house of enthusiasm for professional change and growth, Stenhouse (1975) made the observation that professional development and curriculum development are intimately linked. This key association is being utilised by the development of the TechnoScience2000+ resource. A programme of dissemination and development has been implemented so that the interaction of local bodies of teachers at workshops will inform and change the resource. It will also assist in the achievement of personal growth through professional development.

Global outreach through the concept of ownership

The notion of "ownership" is becoming a central aspect with regard to the development of TechnoScience 2000+. A growing core of material has been generated through such measures as teacher participation in local workshops (Parkinson, 2000). Participation leads to ownership and this in turn can lead to implementation. Such a process has been described by Holbrook (1999) as "operationalisation" and is central to the role of making STL a plank for human development and decision-making via the UNESCO declaration of intent (UNESCO, 1994) . Operationalisation is seen as one of the planks upon which STL can be extended to a widening sector of the teaching force. Workshop activity has been undertaken so far in several locations in India and is set to extend into the Americas later this year. Science teaching associations are also playing a crucial role in awareness-raising. Workshop activity adds to the inclusiveness of a potentially global resource. Teacher-participants are able to articulate fresh approaches to STL issues, for example by identifying socially-derived contexts in which scientific ideas can be seen to be relevant. Frequently these contexts embrace technological foci and utilise these as a means of raising associated scientific issues. This bonding of scientific and technological experiences has had a significant history of development at primary school level in the UK and elsewhere (Johnsey, 1999; Venville et al, 1999), and is the basis of many curricula worldwide. It is this close association of course, which has provided the name for the TechnoScience2000+ resource itself.

Some considerations regarding ODL measures through ICT.

Any overview of a resource claiming that development towards ICT-enabled delivery of courses and informal learning measures is free of problems would be misleading.

Whilst WWW delivery of resource material may be increasingly possible, reservations must be expressed about the ways that users are able to interact through appropriate learning styles. Evidence already exists regarding the slowness of students to readjust to new learning conditions (Gibbs, 1981). This effect may be compounded in the move to Internet learning, for users may not only be unfamiliar with new ways of working, but also actually become "lost" in more complex systems (Kirkup & Jones, 1996). TechnoScience2000+ has been carefully structured in an attempt to minimise navigational problems, and workshop sessions for teachers with no Internet experience whatsoever have yielded encouraging results for first-time users. But this is no reason for complacency. Virtual learning environments bring new challenges to teaching and learning for all stakeholders (Richardson & Turner, 2000).

Informal professional development

Self-development through informal measures is a pattern of learning that all of us undertake in our daily lives. Whether we are aiming say, to drive more safely or swim more efficiently, we can achieve these objectives by both formal and informal means. We can enrol on face-to-face courses to achieve self-improvement, or use alternative channels such as watching a video or reading a book. With informal measures, the time, pace and often the place in which learning is initiated can be determined by the learner. Also there is no fear of embarrassment for asking apparently superficial questions.

Informal learning is a perfectly natural mechanism and it can be enhanced with electronic aids such as the Internet. Interaction through online learning can be undertaken with apparent anonymity. No-one is seen as the judge of the appropriateness of queries into hypertext: they can be as superficial_or as deep-- as the learner-participant wishes.

TechnoScience2000+ is currently being utilised in a hybrid formal/informal model for the delivery of a modular, Internet-based post-graduate teaching course in the UK. It has been built into individual learning programmes for trainees so that they may make accelerated, non-traditional (that is non face-to-face) progress to a teaching qualification. The course outcomes are formal in terms of government-specified standards that trainees must achieve to attain qualified teacher status. However, learning routes are in the hands of the trainees. They can choose how often to study, where to study and when to study. A range of training resources are offered, including TechnoScience2000+, but the trainees decide which resources to use. This learning model has another additional benefit. The initial training measures through resources such as TechnoScience2000+ are undertaken alongside teaching duties in schools. This means that there is a close association between the gaining of theoretical knowledge and professional application. These aspects serve to support each other for mutual benefit (Eraut, 1994).

Just as informal learning routes are set to grow due to the influence of the Internet, so too will professional development opportunities see a shift which embrace this medium. Bardonwell (1999) sees this as part of a trend towards "degathered" learning scenarios which are location-independent, learner-directed, of life-long value and of interactive nature.

Within this "degathered" picture of the future of much training, TechnoScience2000+ accords with all the key areas identified by Bardonwell.

Hypertext and new learning routes

The reading of text from books can be seen very much as a linear process. The building of ideas is sequential and is predetermined by the author. It is the author therefore who determines something about the learning style that the reader must adopt to assimilate ideas from the text. With hypertext this sequential, linear pattern is broken. Within the limitations of the hypertext regime, the learner can determine a personal, non-linear route to the gaining of information and is thus empowered with the capacity to choose, to an extent, the learning style which is appropriate for them. TechnoScience2000+ takes full advantage of the capacity of hypertext to accommodate learning styles that can benefit from non-linear learning routes. The resource is structured so that the reader may be guided through a sequence of events, yet not constrained by them. There are opportunities for accelerated learning and reinforcement. Hypertext links through conceptual key words lead the reader to banks of information as required.

The opening up of new Internet-based learning routes offers tantalising glimpses of future modes of in-service training. Using the Bardonwell model there could be a shift towards global training programmes. Distance becomes immaterial if the click of mouse can send information ten kilometres or ten thousand kilometres for the same cost of an email transmission. Discussion, which is of such great importance in the clarifying and embedding of ideas, has been seen as the exclusive domain of face-to-face teaching. Internet is set to change this. Computer conferencing may accommodate 'chat-room' participants on a global scale. Broadband communications promise the development of virtual face-to-face discussions through streaming video links. Like many aspects of ODL via Internet measures, conferencing is not without problems of student acceptance

(Blanchfield, Patrick & Simpson, 2000) and would need careful consideration to be included in the TechnoScience2000+ programme.

Currently, TechnoScience2000+ does not take account of some of the most recent WWW-enabled presentational technologies. A resource which is saturated with high density illustrations, moving sequences and sound effects is, in the context of the WWW environment, of an exclusive nature. However, as the resource develops it seems likely that multiple versions will arise, each of these enabled for various levels of WWW access and thus serving differentiated levels of Internet communities. Further enhancements such as chat room facilities and hyperlinks beyond the TechnoScience 2000+ resource may develop on a trial basis.

Professional development through hypertext development.

Development of the TechnoScience2000+ resources through workshops with teachers has yielded unexpected benefits. One of these is the realisation that the hypertext pathways upon which TechnoScience2000+ is constructed can be used as templates for alternative ODL structures. Editing of TechnoScience can be limited to the changing of individual words or phrases or more radical measures.

If extensive editing is carried out, whole sections can be replaced with new text and illustrations, but retain the original hypertext linkages.

Workshop activity can thus yield benefits beyond "operationalisation". Through measures such these, teachers are not just changing curriculum elements but becoming empowered with new ICT skills and via TechnoScience2000+ gaining the capacity to change the culture of learning for colleagues.

TechnoScience2000+ seeks partners who can enter this exciting phase of growth, change and development. Perhaps one of the aspects upon which evaluation evidence on the effectiveness of TechnoScience2000+ should be drawn is the extent to which later versions of the resource have deviated from original texts.

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Learning and Self-Evaluation in Physics by Communication and Information Technology

Adriana Jacob, Mariana Astilean, Luminita Chicinas, Dorin Ungureanu
"Babes-Bolrai" University, Cluj-Napoca, Romania
iacobadr@yahoo.com, mariana_astilean@hotmail.com,
luminita@isjcj.ubbcluj.ro

INTRODUCTION

Nowadays the perspective opened by the Internet in the educational domain is unanimously accepted. That is why a careful analysis of the information and communication technology is needed. The main directions are:

- a new dimension of the person's (child, adult) level of socialization from the perspective of its opening to communication and information
- developing the instruction's virtual environments: on-line, CD-ROM
- developing the distant education
- creating new educational sites in Romania
- being a part oh the existing educational sites by taking part to workshops in specific domains that are of common interest.

The educational reform involves a change of the educational process from the informational character to the formative one; it means that the formative education's learning and evaluation methods will be amplified.

The Web is certainly excellent for distance education, because it provides on one hand an easy access to an objective and interactive evaluation, step by step, for learning and on the other hand, the pupils become self-motivated for learning.

This self instructional system encourages the pupils performance, by giving them the possibility to respect his own rhythm of understanding and applying of what he studies, promoting a non equal level of formative instruction.

The self-evaluation system through specific, measurable methods allows pupils a self-quantifiable progress, stimulating his needs for over fulfillment.

PRESENTATION OF THE APPLICATION

These kinds of media are used to promote a large understanding of science, being a popular one. It can be usefully applied in the classroom improving the motivation. Such of application represent an innovative addition to the campaign to promote the public understanding of science. It is a mean that help to show the importance of physics in our lives and the power of physics to explain why things are as they are.

In this work, we promote an alternative educational method equally useful during the physics classes, as well as a self-instruction and self-evaluation environment for pupils. The *Internet browser* makes this method easier.

Taking into consideration the principles mentioned above, we realized an accessible application for the web browsers, which allowed a compendium kind approach to the domain to which the content is addressed, as well as an interactive tackle through the problem situations.

The application is a model that can stay at the base of the modular tackle for the content of physics program; each element contains the following features:

- minimal amounts of text, so that they are accessible and inviting to learners (of any age) with limited literacy skills
- scientific ideas are applied in everyday situations, so that learners are challenged to make connections between the scientific and the everyday
- the alternative ideas put forward are based on research that identifies common areas of misunderstanding, so that learners are likely to see many of the alternatives as credible.

Web browsers - Netscape or Internet Explorer's type – provide the environment in which the application was developed. To use the application, you need to have a computer connected to Internet or an Intranet network.

The access can be made from a web site level of from a "virtual site" represented by a CD.

During your physics lab, in case you do not have a network of terminals to allow you to have an optimum report (number of students per terminal) you can obtain interactivity and participation of the pupils, if there is at least one computer, by using the LCD (Liquid Crystal Device). Practically, the blackboard by the LCD's screen and the chalk by the mouse and the computer's keyboard are replaced.

Any research that may be of relevance to physics educators has been undertaken from a number of different perspectives.

1. An evaluation of the method as a teaching and learning approach.
2. Use of the method to challenge student teachers' perceptions of approaches to teaching and learning.
3. Use of the method as an assessment strategy.
4. Public access to science through Science on the Underground by Web

There seem to be a number of implications from the research for how the method might be used in physics teaching and learning. These include:

1. *enhancing motivation* - Although levels of interest in science, including physics, are generally high in the primary school, this interest tends not to be sustained in secondary school and beyond. Use of the method offers one possible way to sus-

tain this interest for longer, particularly with those pupils who do not learn easily from text-based resources or who are already somewhat disenchanted with school.

2. *providing a purpose for practical work* - There is some debate about the nature and purpose of practical work in schools and how practical work pupils perceive. When pupils use this kind of applications there is a context and a purpose for investigating the situation, with the use of scientific skills closely linked to the development of scientific ideas. The investigations carried out are directly linked to the learner's existing ideas.
3. *emphasizing the applications of science* - One of the reasons why physics is perceived as difficult (and frequently male-oriented) by many learners is that it is viewed as dealing with abstract concepts that apply only in ideal theoretical situations. Some learners feel that they have to learn a lot of theory without ever considering how this theory might apply to the real world. This kind of application represents an attempt to ask some of the questions that learners might like to ask if they think about their everyday lives. Through this method, physics concepts can be given a breath of life.
4. *enabling learners to assess their own level of understanding* - Such of method offer an alternative technique that can be used in exactly the same way with student teachers and with pupils in school. Part of the value of this technique is that it links together the stages of identifying areas of uncertainty and finding out more in those areas. In this respect, the technique also acts as an ***active learning tool*** rather than simply as an assessment strategy.
5. *promoting public awareness, interest and understanding in science* - The Science on the Underground project is a large-scale example of an approach that can be very successful on a smaller scale. The *browser environment* provides physics educators with a strategy that can speak to the public in ways that they find interesting, accessible and challenging. Underground travelers are not renowned for talking to each other, and the Underground might not be the most obvious place to set about improving the public understanding of physics.

Thus, Internet browsers offer to the educational environment the most favorable means of teaching, which is exactly the aim of the new modern information and communication techniques. That is why we sustain the idea that Internet itself may be the source and the mean of any self-instruction level for pupils. Using the Internet, educational process can be moved from classroom to any pupil's apartment. That is how we can beat the fifty minutes rigidity of a class.

The segment used for our application was ***electricity***. The contents' organization is a modular one, allowing the teacher to use different levels of difficulty in the teaching process situations. These situations are given by descriptors of performance to the circles of education and follow the operational objectives specific to every circle.

We thought the application to be functional by being orientated from the problematical proposed exercises by identifying the knowledge obstacles, to the theoretical elements included.in the Compendium part, which will allow a right understanding of the studied phenomena.

Made as a multimedia instrument, the application itself does not put any obstacle in front of the level on which we approach the information. The pupil can study separately the Compendium part, the exercises, obtaining specific knowledge, or he can improve his general culture finding out data about the life and the activity of the scientists who, throughout history, had an important contribution in this domain.

The primordial concepts, the notions and the specific aspects of some physics phenomena are contained in the Glossary. Here you can find in the context the explanation of these phenomena.

This application contains also a News modulus made up of a list of Internet addresses with the associated links that allow the direct web access to the sites from which pupils can get supplementary documentation.

The application's architecture type is like a pyramid pointing to the theoretical area as well as to learning through practice area.

We can approach any element using the Contents which, by a system of links, allows both the recall of the previous acquisitions, as well as the access to the next level showing the entrance level's flexibility. In addition, we suggest a content navigator organized on elaborated levels for an unassisted approach.

Interactive learning modulus is based on an easy performance evaluation instrument for pupils regardless of their age and skills. You can simply give them a period to work, and after that, you are able to see their knowledge level.

CONCLUSIONS

You can find the properties of this tool in:

- access on different levels of complexity,
- interactivity, specifically instructional techniques,
- examples and possible learning ways,
- the access to a synthetically information which can be permanently updated, adjusted and improved using the cognitive feed-back,
- going back to any level,
- evaluation and self-evaluation,
- directed documentation vector finding obstacle knowledge,
- a vector involved in the development of distant education.

From this point of view, the Internet Navigator can become an interactive learning tool, which allows not only knowledge acquisition, but also obtaining the necessary skills for an appropriate learning and cultivation of scientific attitude by developing the curiosity, skepticism and an open minded view.

A Student-Centered Learning Project for Distance Education

Vasso Stylianou and Andreas Savva,
School of Computing, Intercollege, Nicosia, Cyprus
vasso@intercol.edu, savva@intercol.edu

ABSTRACT

In distance-learning courses the students are responsible for their own learning. They are self-regulated and able to define their own learning goals and evaluate their own achievement. To succeed the tasks must be challenging, authentic and multi-disciplinarily. This paper presents a distance education program that is under development by the authors. Emphasis is placed on performance-based assessment and interactive instruction, so that it actively engages the learner and is generative. Thus, the role of the teacher has shifted from the primary role of information giver to that of facilitator, guide and learner.

Keywords: Distance Learning, Technology, Web-Based Platform, Education.

INTRODUCTION

Some recognize revolutions before than others, some are eager to follow the trends of times more than others, but when it comes to technology the forces that are exercised by the environment are sometimes so strong that one cannot ignore them or exercise any resistance. In education, MIS researchers have been acknowledging a slow infiltration of educational technology in our classrooms and curriculum and insufficient use of technology in the infrastructure of academia[1]. On the other hand, educational researchers evaluating how using technology affects the learning process, report back saying that though the attitude of educators and mostly learners towards information technology (I.T.) is positive, the effect on achievement, productivity, and learning coming from the use of I.T., is more or less neutral[2,3,4]. These same people also caution us to the careful design and deployment of such instructional tools and methods and emphasize that:

> "Even when computer-assisted learning is appropriately designed and presented, however, it is no guarantee that learning will occur." And further on, "Regardless of the number or sophistication of computers and computer-related devices available, it is this interplay of learning style, motivation, and prior experience that will determine learning." (Mellon, [5])

The multiplicity in learning and teaching, the extreme power and ubiquity of technology, make educators feel the pressure to not only teach people to use the technology but also to utilize it in their teaching to the maximum extent possible. At the same time they remain skeptical about the expected outcome. Let us all remember that "... these new instructional media (should) be added to the tool kit of media that we have. Then teachers and learners will be able to choose the instructional medium that best accomplishes goals within the constraints of a given setting." (Levin et al., [6])

It is also important to emphasize the need for assessment of our results when new methods and tools are implemented in our educational system. Or even better "Educators managing school technology programs should focus on what results are desired and choose the best techniques to measure progress." And this is so because "With all the rush to get technology into schools, it's important for someone to be paying attention to where it can be most effective and best utilized." (Carter, [7])

The conclusion from all these, often contradicting viewpoints, can be that we say Yes to the use of modern educational technology and specifically the Internet, but we should be careful on the implementation and evaluation of its deployment.

A WEB-BASED EDUCATIONAL DELIVERY SYSTEM

"For practicing teachers to become experts at using technology in their teaching, they need to learn how, to use multiple instructional media in service of multiple instructional goals."[6] Before the "how", teachers need to become aware of "what" instructional technology is available in order to select tools to fit the task at hand. Under the scope of this project we intend to develop a tool by which the instructor can provide the rich environments and learning experiences needed for collaborative study. Our effort is empowered by the belief that modern education must and will embrace technology within its pedagogy. It is considered that two primary forces drive the need for technology within education. These are:

a. The inclusion of technology provides the opportunity to enhance traditional, face-to-face, teaching or form the core guidance tool for distance education programs.

b. The use of technology can significantly reduce the cost of education, presenting opportunities, particularly within developing regions, to those who might otherwise not be fortunate enough to obtain a structured education and its inherent benefits.

The project will blend both old and new technologies to form a hybrid teaching mechanism, based on engaged student-centered learning. The objectives are as follows:

- An easy and friendly web-based platform which instructors use to develop/modify curricula content. As a supplement the system places emphasis on linking and collaboration with relevant educational web sites.
- To develop a front-end web-based educational delivery system, which is easy, friendly and engaging for learners. The structure will be designed to foster a strong

sense of community.

- To develop an educational tool that is practical, flexible and engaging while reducing the overall cost of education. It is hoped that the system will be suitable for learners in remote areas and also attractive as a classroom supplement.

The platform will be based on a customised browser (Netscape and/or Microsoft Explorer) and thus, will be familiar to users. The browser platform will essentially pull the various aspects of the educational tool. The key aspects are:

- Interactive web pages with Institutional course content and links to other relevant sites. This site will include the study guidelines and agenda as per the instructor.
- A forum site, providing an asynchronous means of communication between students and faculty and student communication amongst themselves.
- A web library, in which all instructor selected web links are catalogued and placed in a database.
- An administrative section in which course details, student and faculty contact information and other relevant information can be found.

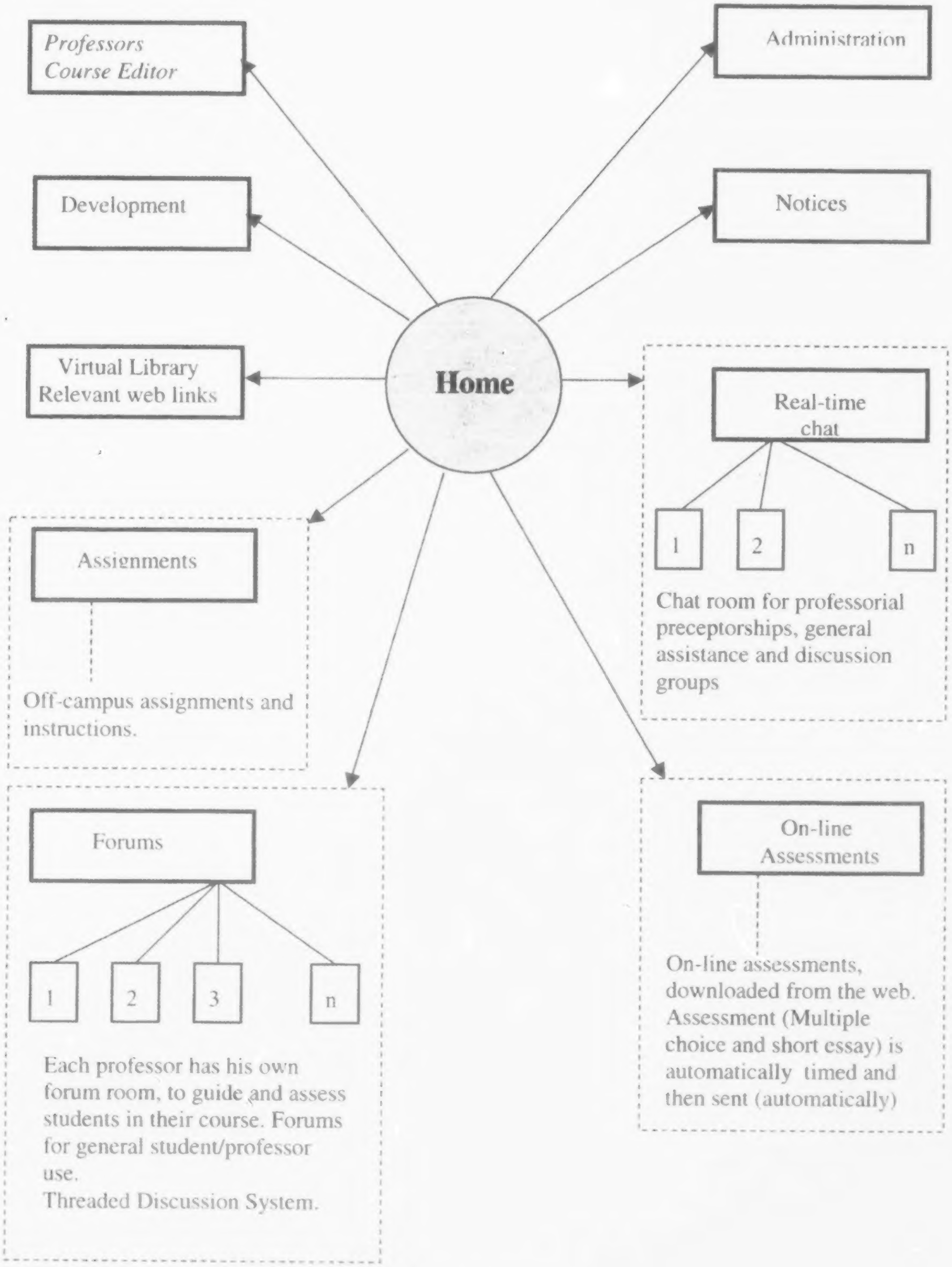
Figure 1 of this paper represents a diagrammatic model of the system features.

It is believed that there is potential for this versatile educational delivery system to have considerable appeal to institutions, businesses and individuals worldwide. The platform is to be updated, modified and improved on a regular basis in order to strengthen its academic as well as its commercial value. This could also be translated into various languages, further enhancing its appeal.

The very essence of the project is to develop a delivery system for educators that is, in terms of content and its arrangement, built by the Educational Institution and is easy to use by both instructors and students alike. There is clearly, too, significant potential for collaboration between institutions using the same delivery system to share content, e.g. the web-library databases, which can reduce the time and cost of content development.

CONCLUSIONS

In 1995-96, Colorado teachers ranked the importance of 10 broad areas of computer competency[8]. One of the 10 competency areas was referring to the Internet looking for "Knowledge of new technologies, including software programs, databases, spreadsheets and Internet". The competency area ranked highest by teachers was "Develop instructional methods that utilize technology to enhance students' skills, enhance hands-on experiences, manage different learning strategies, and develop higher thinking skills". A more recent research showed that making computers an integral part of curriculum and instruction has the greatest importance for teachers[9]. This paper is presenting a challenge to educators to re-design their courses whilst experiencing themselves and their students the diversity, modularity, and freedom of a Web-based


Professors
Course Editor
Administration
Development
Notices
Virtual Library
Relevant web links
Home
Real-time chat
1
2
n
Assignments
Forums
1
2
3
n
On-line Assessments

Chat room for professorial preceptorships, general assistance and discussion groups

Off-campus assignments and instructions.

Each professor has his own forum room, to guide and assess students in their course. Forums for general student/professor use.
Threaded Discussion System.

On-line assessments, downloaded from the web. Assessment (Multiple choice and short essay) is automatically timed and then sent (automatically)

Figure 1. A Student-Centered Learning Project for Distance Education

teaching environment. Lets not forget that everybody's intention is to work "smarter" and not necessarily "harder".

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Elements of Project Method by Using the Web as Teachware in Chemistry Education

Martin Bílek, University of Hradec Králové,
Dana Kričfaluši, University of Ostrava,
Antonín Slabý, University of Hradec Králové,
Czech Republic
martin.bilek@uhk.cz, dana.kricfalusi@osu.cz, antonin.slaby@uhk.cz

Key words: basic school chemistry education, WWW, Internet, project method of teaching, chemistry of everyday life.

INTRODUCTION

The education of natural science subjects is the focus of many discussion concerning the changes of rationale, content, methods and forms of education at present time which can be characterised as time of coming information and communication technology. Web based information technology is not only the domain of the universities but start to influence significantly the life of primary, secondary and high schools. The number of Czech schools connected by the dedicated line is increasing rapidly, there is an enormous interest of pupils of all age groups in the Internet, the computers get over the use in specialised subjects such as Informatics and Computers and bridge various subjects. The lack of methodological materials devoted to various ways of using of information bases and sources of the Internet appears to be a significant obstacle to spreading various reasonable and valuable application of ICT at schools. Similarly teachers are not sufficiently prepared for the use of the information technology in both user and creative areas. Implementation of the new technology requires progressive methods of education, which will make use of offered tools with attitude towards cognitive psychology and educational technology (hypertext, self-learning, cognition mapping etc.). There should be used educational strategies and systems capable to simulate as truly as possible the process of education. They enable to create individual environment for each student that can motivate, respect her or his style of education, interests and needs. The teacher should be able to select suitable materials and organise the access to the offered information. The educator also ought to avoid problems and hazard of the Internet and prevent aimless surfing mainly by using special projects, evoked problems and creative approach. Brestenská and Silný (Brestenská B., Silný P. 2000) express basic philosophy of the attitude towards the use of new information and communication technology in the education of chemistry in the following steps:

- to recognise (learn) the services provided by the Internet and learn to make practical use of them: information – creative activity (teacher, student),

- to select the parts of the curricula of chemistry education which can be suitably and interestingly taught using ICT (teacher),
- to search the sources of information using well defined key words (teacher, student),
- to select and archive gained interesting data or realise direct presentation found in the Internet (teacher, student),
- to analyse didactic possibilities of the use of gained information and ways of processing gained information – maintain information accessible (teacher, student),
- to support and widen individual and active work of students while their using ICT in the form of projects, workshops, reports etc. (teacher, student),
- to stimulate international collaboration of students and teachers (international educational projects, distance forms of education etc.) (teacher, student),
- to create web pages step by step presenting the results of students and teachers and school work, results including international co-operation (teacher, student).

Internet and especially WEB based education breeds a row of specific features, which has not been properly discussed or concerned only partial or marginal interests of educators and educated students. One of them appears the problem of the new attitude to the problem of communication in educational process. S. M. a K. L. Miller (Miller S. M., Miller K. L. 1999) consider this quickly developed area of Web based education one of the meaningfully determinative factors for setting up of educational aims. They mention two fundamental types of communication teacher- pupil, and pupil - teaching material. While first type of communication is apparent (manifest) and is a special form of typical work in the classroom to use new technology (e-mail, e-conference, etc.), the second type of communication pupil - teaching material is hidden and presents new possibilities of realisation of the two cognitive paradigms: cognitive processing and cognitive constructivism.

For cognitive processing paradigm raises the need of the following prime educational aims:

- to present the teaching material in structured form (hierarchical structure of information, hypertext),
- to ensure the possibility of feedback (find out the level of mastering the subject matter),
- to ensure the communication between the teacher and the pupil during mastering the subject matter,
- to ensure the communication among pupils during mastering the subject matter.

For cognitive constructivism paradigm are important mainly the following educational aims:

- to present the subject matter as a situation solving of problems in real context,
- to ensure possibility of thematic co-operation among students (discussion, multivalued perspectives and evaluation),

- to ensure the possibility of pupils own formulation and revision of conclusions gained during problem solving,
- to create possibility for changing the role of a teacher to making easy and coaching of pupils own knowledge construction.

Both paradigms in the stage of realisation using adequate strategy assume proper selection of the type of communication (between two subjects, among more subjects etc.) and time aspects (synchronous, asynchronous).

Consequently the Internet means together with its quickly developing technical infrastructure enormous potential for education of natural sciences and our challenge is to use at least part of its possibility and capability.

Web as Author Systems

Web (World Wide Web - WWW) is so widely used expression and abbreviation that it need not translated into Czech. The explanation says that it is something like a cobweb spread all over the world. The WWW system consists of mutually connected computers. Using hypertext references (the most common type of hypertext is help in Windows) is one way that enables their connection. Let us suppose the typical situation that there exists one main page on some WWW server, which is displayed after connection to that server. On that main page there are references to other pages belonging both to the same server and to other servers. WWW pages support graphics. HTML (Hypertext Mark-up Language) is one wide spread way to create WWW pages. This language makes it possible to put in not only texts of various forms, sizes and attributes but also enables to include pictures, sounds, animations and other components into the WWW pages. Objects included into the page may serve as a link to another page. WWW service uses HTTP protocol (Hypertext Transfer Protocol). WWW is based on the client-server architecture. So-called Web-browser is necessary software for each client enabling him search various WWW pages. The best known Web-browser competitors are Netscape Navigator designed by Netscape and Internet Explorer designed by Microsoft. At present WWW is a crucible Internet service and consequently it is not possible to avoid it even in educational system (Cyrus P., Slabý A., Bílek M. 1997).

Author systems are professional programming devices, which make it possible for software creators to use the whole potential of hardware and to create professional software products without mastering of more complicated specialised programming languages (Bílek M. et al. 1997). At present many of them have capability to create WWW pages in a user friendly way. Moreover there is a number of HTML editors of various quality, price and comfort available on Internet for us to use. Many of them are freeware or shareware, some are testing beta- versions and some valuable and friendly programs.

Elements of Project Method in Teaching Chemistry

Present state and perspectives of teaching of natural science and also related attitudes of the whole population to natural sciences bring with them the need to think about possibilities of more attractive ways of presenting new information, which touch both methodological views and content of the above mentioned process. To be capable to explain elementary phenomena surrounding us in everyday life is an actual need from the point of general education and is thus a rightful requirement to create basis for natural science teaching. The attitude of many people towards chemistry is negative nowadays. The term "chemistry" is for them connected with matters negatively influencing the nature and particularly living organisms. On the other hand chemistry plays its part in upgrading life standard of living (fertilizers, insecticides, pesticides, synthesis of new pharmaceuticals and development of new materials). This role is, however, unfortunately often ignored. The problem of the devastating of the environment is not caused by chemistry itself, but it is caused by misusing of chemical products, by irresponsibility or by neglecting of working procedures and regulations (improper dosing of fertilisers, pesticides, abusing of medicaments, etc.). The above mentioned characteristics of general opinion are very often transformed into pupils' thinking and attitudes towards lessons of chemistry. This is mostly the case of pupils who do not regard chemistry as their main subject. A teacher of chemistry faces a serious problem: how to make chemistry interesting in an attractive and unforced form (Bendel E. 1987).

Lessons of chemistry in basic education may become more interesting if we succeed in emphasising the connection between the presented subject matter and phenomena and processes which pupils meet in everyday life. This is mainly the teachers_ task because it is impossible for the textbooks to cover everything. The textbooks only cover general information or essential facts and they often lack motivation power. Many experiments, which illustrate phenomena and processes of everyday life, may be carried out with simple and easily available substances and using elementary equipment. Chemistry is really everywhere and particularly can be found in situations and places where an ordinary human being would not suppose it to be. From the view point of many educators of chemistry a particular system incorporating the chemistry of everyday life into topics and completed with corresponding simple experiments would be desirable. For this either the system should be made part of the present curriculum or new projects based on that should be worked out. This is the way to create new teaching projects. Some of such projects would present, for instance, chemistry of washing, cleaning, food, textile materials, etc.

Another type of classification is also possible. Let us mention for example classification focussed on methodological approaches:

1) Analytical approaches (What is it made of...?).

2) The preparation of some chemicals from simple materials (How to make...?).

3) The impact of the particular chemicals (What effect does it have on...?).

One may also imagine the teaching project "Chemistry in Everyday Life" aimed at both content and methods. Individual projects can be called "Chemistry from Dawn to Dusk" or "Chemistry Around Us", etc.

To bring above mentioned ideas into effect a teacher should search for every possible way to do it, including the use of modern media. Internet belongs undoubtedly to them. Its immense capacity provides a lot of ideas and suggestions to use (Brestenská B. 1998; Ganajová M. 1998; Hynek J. 1999; Juhász J., Matulík D. 2001; Mikulecká J., Milková, E. 1999; Turčáni M. 2000).

Project: Chemistry of One Day

In correspondence with the above mentioned ideas we focussed on the "mini-project" named "Chemistry of One Day" which illustrates various types of encounter between a pupil and chemistry (in its common form, i.e. objects of everyday use, consumption of every day materials, products and inventions etc.).in everyday life and in a course of one day. (Kopřiva J. 1999). The mini-project is not restricted to one sphere only. There is no sole method. The link is here done through the time interval of one day. Several factors, which specify the characteristics of individual experiments, were agreed upon:

1) the experiments must include only common things and processes from pupils' everyday life - e.g. washing hands etc.,
2) chemicals used during the experiments must be easily accessible and must not be dangerous or poisonous, etc.,
3) the experiments must be easily realised without using special chemical equipment (simple equipment needed for the experiments must be accessible or producible),
4) the experiments themselves must not be too complicated.

The "Chemistry of One Day" project represents an ordinary day. It can also be taken as a starting point from which other projects may be developed. In the first phase the project was divided into several parts according to characteristics and use of individual chemicals: food, washing, health care and protective means, environments, dyes, etc.

WWW pages related to the project consist of various kinds having various roles:

1) motivating opening section - a _clock" with links, the colour of each part is a link to related experiments and information,
2) links to directions (how to carry out simple experiments related to individual parts),
3) links to firms' pages presenting products related to individual parts,
4) information (theoretical principles and news) about described areas.

Many simple experiments have been included into the projects. The topics are as follows:

- Egg white analysis.
- Natural fat analysis - elementary analysis of pork fat.
- Saccharine analysis - elementary analysis of corn flakes.

- Albumen condensation.
- Evidence of C-vitamin presence in food.
- Starch extracting out of potatoes.
- Chromatographical separation of green colour used in markers and its elements.
- Evidence of CO2 presence in exhaled air.
- Suntan oil-making process.
- Attributes of soap.
- Washing powders contain agents, which soften water.
- Washing powders contain agents, which remove stains.
- Shampoo-making process.
- Toothpaste-making process.
- Etc.

The topics are associated with links to adequate WWW pages (they may include the presentation of the firms, similar education and school projects in the word, principles of the above mentioned processes, etc.)

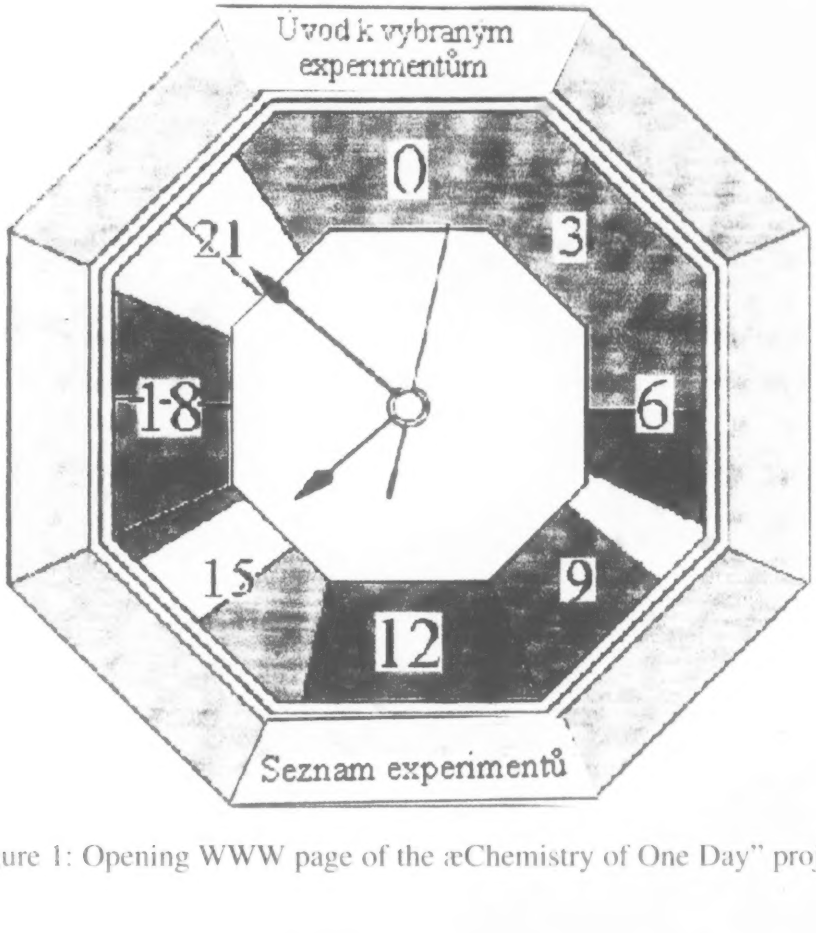

Figure 1: Opening WWW page of the æChemistry of One Day" project

Example of linking structure in the field of "Washing"

I. Experiments

- Soap solution is soaking skin.
- Soap decreases surface tension of water (Fig. 2).
- Soap solution has emulsion effect on oil and fat.
- Soap solution plays an active part on the borderline between oil and water (Fig. 3)

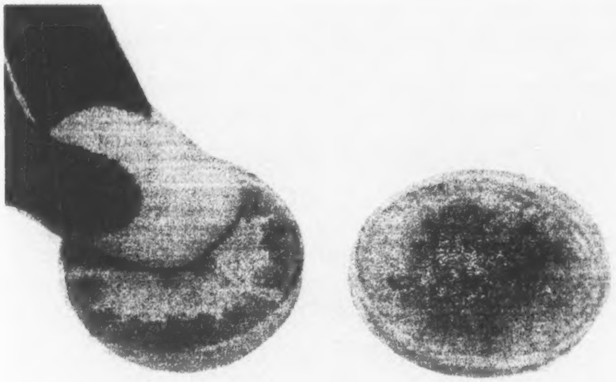

Figure 2: Soap decreases surface tension of water

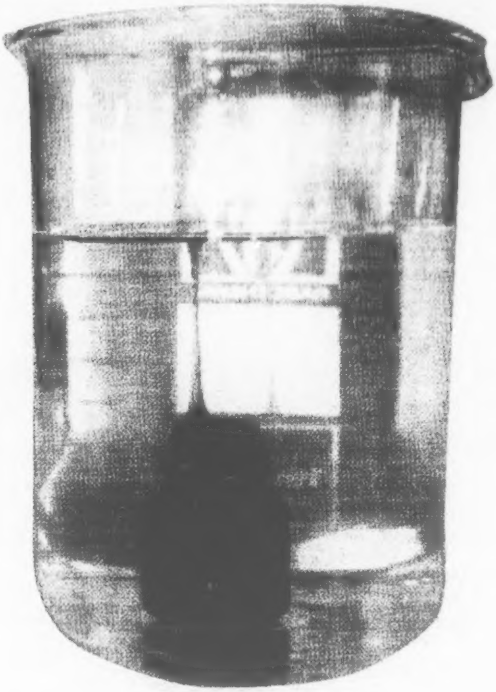

Figure 3: Soap solution plays an active part on the borderline between oil and water

II. Related links

- Alfa Classic - sanitary devices, liquid soap production and washing and cleaning devices production (http://www.alfaclassic.cz/frames.htm).
- Hygos Service - bathroom equipment (http://www.hygos.cz/).
- _empo, s.r.o. - cleaning, washing and desinfective devices, painting materials, diluents ... (http://www.rempo-vega.cz/).
- Setuza a.s., - one of the biggest and oldest Czech firms plant- oil food, consumer chemicals and drugstore goods (http://www.setuza.cz/).
- Step a.s. - devices for water conversion and softening filters. (http://www.steptrutnov.cz/).
- Soap making ...The way we used to do it. (http://lis.ab.ca/walton/old/soapold.html)
- Soap making. (http://millenium-arz.net/News_files/INFO_Files/soapmaking.html)
- Etc.

Conclusion

The primary aim of the project was, in its first phase, to create initiative materials for supporting teaching of chemistry at basic schools (and also for supporting the chemistry teacher' training). In addition it aimed at practising and presenting a new possible role of the teacher. The new role lies in managing the relatively individual activities of pupils by forming so called "information about information", including methodological aspect, which is very important for natural sciences even in the age of information and communication technologies. The project is displayed and accessible on WWW pages of the Department of Chemistry (Pedagogical Faculty of the University of Hradec Králové, Czech republic) as part of link "School Chemical e-Laboratory" - http://www.uhk.cz/chemie (link – "E-laboratoř" – "Low-cost – experimenty") - and it is open to further internal as well as external additions and revisions and changes.

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Interactive Training Network for Education in Technology and Biomedical Applications

V. Zacharopoulos, L. Naoumidis, and Ch. Athanasaki-Michailidou
Institute of Crete, Heraklion, Crete, Greece
vzachar@techmed.teiher.gr, naoumidi@med.uoc.gr

P. Slobodsky, Halomda Educational Software, Israel
halomda@netvision.net.il

E. Kritsotakis, Regional Education Centre, Crete, Greece

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Technological education is a high-cost process that requires big volumes of demonstration materials and laboratory equipment. The education institutions often experience deficit in this kind of equipment, as well as in appropriate funding.

The progress in development of computer applications delivered through Internet, has provided a possibility to correct these drawbacks of technological education. Latest developments in the fields of software and networks allow to create and to deliver to the most distant areas any virtual laboratory demonstration, which may even leave behind the real laboratory experiments, due to the possibility of interactive participation of every student, which is not available in conventional laboratory demonstrations.

In addition, introduction of computer didactic methods concerns theoretical disciplines as well (for example, mathematics), and creates the possibility to bring them up to qualitatively higher levels, due to interactive training, computer simulation of the studied processes etc.

The aim of the present communication is to propose international cooperation between educational institutions of Mediterranean countries with the following objectives:

- Creation of a development core for regional network of distant learning in technological education;
- Establishment of international cooperation in the area of interactive education programs for various technological fields
- Joint development of interactive education programs in technological disciplines, as well as in mathematics and biomedical (1) technologies, in the languages of the

partner countries.

- Creation of computer education network in technological and theoretical disciplines, as well as in biomedical technologies, available for regional education institutes.

Following these objectives, the project is supposed to be implemented in three steps. It should be stressed out that every step has its own separate aim and deliverables, and may be considered as a separate sub-project.

The first project stage will concern the high-school education programs. Following educational material will be developed and tested through the newly-developed local educational networks:

- An Internet-based course in physics, based on computer simulations of physical phenomena, guided interactive simulations of basic physical experiments and labs. The course will consist of ten programs covering the main subjects of mechanics, optics, electricity and magnetism. It will be possible to run the programs both from CD-ROM and strictly from the Internet.
- A course in mathematics including: Elementary Algebra; Fundamentals of Plane Geometry; Functions, Graphs, and Derivatives; Fundamentals of Analytical Geometry; The Basics of Statistics; Logarithms; Trigonometric Functions, Equations and Identities; Introduction to Linear Programming; Complex Numbers; Fundamentals of Differential Calculus;

The educational material and relevant software will be available for approbation by participating educational institutions through the Internet.

In the second phase of the project, based on the results of the first stage, the educational material and relevant software will be extended to the higher educational level. New courses will be added, including higher mathematics, descriptive geometry, special physics courses, lasers, medical instrumentation, telemedicine et al.

The courses "Medical Instrumentation" and "Telemedicine" have been chosen with the aim to meet the constantly growing demand of labor market for specialists in medical technologies (especially, in medical electronic instruments and telemedicine). The market experiences deficit in engineers and technicians specialized in medical instrumentation, telemedicine, etc. The growing number of modern hospitals, as well as the increasing quality of medical services, are constantly raising the demand for the personnel specialized in the use and the maintenance of sophisticated medical equipment.

The course "Medical Instrumentation" is one of the major courses of the specialization "Medical Technologies". It will be aimed to acquaint the student with the principles, applications and design of the medical instruments most commonly used in hospitals. The emphasis will be given to fundamental principles of operation and general types of equipment. Main applications for each type of instrument will be provided. In addition to the main text, a substantial part of the material will be given using various multimedia means (video, sound, photos, graphics/drawings). Most topics will be supplied with special interactive diagrams. The course will contain homework problems and interactive tests designed to cover a wide variety of applications.

The aim of the course "Telemedicine" is to provide basic knowledge about computer networks and data communication with applications to health care. Emphasis will be given to message handling including text, images, signals and sound, as well as to methods and tools for communication of multimedia objects. The course will include an introduction to computer applications in medicine, and a survey of health information systems, electronic medical records, information retrieval and standards. Particular emphasis will be given to electronic medical record. A hands-on access to a real electronic medical record system will be provided. Other important course topics are computer networks, communications protocols, client-server architecture, interfaces to databases and database optimization, Internet, computer security.

All didactic material will be categorized and then uniformly digitized with the intention of saving it on a computer (server) for global access. The hypertext-formatted material will be organized as HTML documents with text, images (photos and graphics/drawings), video and animation files with narration (in various languages) plus questionnaires and feedback forms for every topic. This format will ensure that all computer systems (Windows, Macintosh, Unix/Linux) can be used for the retrieval of this information, as long as they incorporate a web browser (software application), something that is very common these days. Still images (photos and graphics/drawings) will be saved as JPG compressed files, sounds as WAV files, while video files will conform to the MPEG format, helping keep download times at the minimum levels possible.

The user will have to be familiar with only a web browser software application in any operating system. By visiting the web site, he/she will be presented with a main menu leading to various choices/topics in a structured (tree style) categorization. Text will be supplemented with images at the right points. Images will be both photos and graphics designed to enhance the user's understanding of the current topic. If required, audio recordings in many languages, narrated slide shows and videos will be available for download with a simple click of the mouse inside the same page. An online glossary of related terms will always be available, as well as questions and feedback forms which will be useful for the evaluation of each presentation, leading to future improvements and enhancements/additions.

All simulations will be supplied with explanations, and the users will be provided with a possibility to participate in a so-called Physics Forum, where the observed phenomena are discussed by the participants. A special Science Conversation Tool will be developed for effective management of Physics Forum.

In the third phase of the project, the developed didactic material, approved in the preliminary trials through the Internet, local networks and CR-ROMs, will be integrated into the ring network around the Mediterranean sea. This network will be created within the project WAVES (programme EUMEDIS).

WAVES project plans to use satellite networks and to exploit the high bit-rate available beside the digital television streams. This opportunity will make realistic the exploitation of this channel for a distribution of e-learning reserved streams for professional training. Several network operators have their satellite-broadcasting zone covering Euro-Mediterranean area. They will be interested in optimization of their resources especially with delivery of a new additional value-added service.

The project WAVES will promote the generation and the broadcasting of the training sessions. The exploitation of WAVES results will considerably enhance the process of development and subsequent use of training contents.

Δhe electronic training modules will be hosted in a multimedia server, and through a satellite digital TV channel these modules will be accessed by the end users, wherever they are located. Modules will be both non-interactive and interactive. In the first case, the end user will only need a commercial satellite DVB decoder and a TV. In the second case, a return channel is mandatory, to achieve interactivity. The return channel will be based on Internet connections. This scenario provides additional capabilities to the end user, by enabling him/her to actively participate in a real time event, such as watching a lecture on a specific subject and further being able to ask questions.

The WAVES outcomes will be available through Internet. The WAVES project plans to establish its own Web site as a cooperative and communication means, both internal (between the participants) and external (with non-participants).

The participants of the proposed project are interested in the extension of the project team and are inviting regional educational institutions for participation in this promising cooperation.

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Medical Systems Technology: The Experience From a Non-Conventional Tertiary Level Department

Chara Athanasaki-Michailidou, Ioannis Xezonakis, Vassilis Zacharopoulos
Technological Educational Institute of Crete, Crete, Greece
athan@stef.teiher.gr

Abstract. Presented in this paper is the Medical Systems Technology Department, part of the Extended University Programs (PSE) Pilot Project, operational since 1998 by the Technological Educational Institute (TEI) of Crete. Presented are the PSE Institution, the Medical Systems Technology Department and particularly the reasons behind this subject selection, as well as its scopes and aims. The curriculum of PSE "Medical Systems Technology" is presented and compared to similar ones in the international field. We comment on first findings about the Program's operation and give assessment results. Finally problems and perspectives of this institution are discussed.

1. Introduction

Extended University Programs (from now on reffered to as PSE, an acronym of the Hellenic tittle) is a new institution at the Tertiary Education Level (Universities and TEI's), part of the recent educational reform in Hellas. An important change of this reform was the new way of students' admittance to Tertiary Level Education (Universities and TEI's) and the increase in the number of students. The final aim was the absorption by the Universities and TEI's of all High School graduates. The PSE institution was established to serve this aim. In addition, through PSE, new educational procedures, more flexible programs of studies and modern subjects were intoduced. The PSE also promote life-long education, combine low operational costs with high quality education and provide links of studies with the labor market.

2. PSE as an Innovation in Hellenic Tertiary Education Studies.

PSE departments grant a degree equivalent to conventional departmental ones. However they differ in certain aspects, which are new to the Hellenic Educational System. The main differences (1) are:

- Student selection does not follow the usual procedure of entrance examinations. Each department proceeds to evaluate application forms and select students by means of criteria such as rank of graduation etc, set by law.

- PSE present more flexibility than traditional departments in their founding and in their curriculum realization.
- No permanent staff or equipment is required, as PSE can make use of existing traditional department personnel and laboratories. Summer tuition is provided as a means to make better use of existing facilities.
- Students can enroll in part of the program or even only in courses of their interest, while a percentage of enrolled students is reserved for graduates, students of Hellenic and foreign Universities and older persons.
- The maximum allowed number of courses per year is smaller than that of traditional departments because the PSE target group includes older and working people; these people usually desire either a first university degree or a change of field or contemporary knowledge on their vocation in order to improve their chances of employment.

As a pilot project the PSE institution was funded by European Union and Hellenic Government.

3. Medical Systems Technology – Aims and Scopes.

The School of Applied Technology in TEI of Crete, then TEI of Heraclion, proposed, as part of the new PSE institution, the establishment and realization of the PSE Medical Systems Technology (PSE-MST) (2) . This proposal was approved by the Hellenic Ministry of Education and the department was founded, offering two specializations: (A) Medical Instrumentation and (B) Medical Informatics and Telemedicine.

The subject selection took into account the fact of increasing demand for skilled personnel trained in modern expensive and complicated hospital equipment compared with the existence of only one relevant department at the undergraduate level in Hellenic TEIs and Universities. No department exists for the curriculum of the second specialization, despite the geography of Hellas (mountainous inland, islands) which favors and enforces the promotion of Telemedicine for connecting remote rural areas to urban hospitals. There is also increasing need for the development of Medical Informatics, a field which includes, among others, laboratory and hospital services computerization and introduction of electronic health records and medical cards. Note that the promotion of Crete to a high quality medical service center and the development of Telemedicine are among the Region of Crete high priority targets.

The Department's main aim is the provision of studies in a contemporary scientific and technological field with high employment demand. Graduates can cover significant vacancies in the health services as highly trained engineers supporting modern medicine equipment systems. As a result the department and its graduates contribute to a higher quality health service. (3)

4. In Search of Correlation Concerning PSE-MST – Registration and Analysis of the International Situation.

PSE-MST curriculum incorporates subjects varying from pure medical ones (i.e. Biology, Anatomy) to pure technological ones (i.e. Microprocessors, Electronics). Consequently, in order to compare it with curricula from other similar departments, we sought for data related to a wide range of subjects, mainly to biomedical engineering, medical electronics and other similar ones.

In order for a search to be carried out concerning international education in fields relevant to PSE-MST, data have been collected mainly through the Internet, or by common post service. Web browsing has proved to be quite difficult, since the presentation of European Universities on line is fairly limited and poor, while there is no such presentation of non-European countries, except USA. As a result, information comes mainly from USA where the level of documentation ranges from good to excellent, and Europe. Material has been gathered from approximately seventy relevant to PSE-MST University departments, fourty of which grant a first degree to their students.

The absence of encoding of the studies' content is worth noting. In other words, departments with different study subjects appear under the same heading. In addition different subject matter appears under the same name or the same subject matter appears under different course headings. To avoid confusion, the various departments have been classified according to subject matter from their curricula, i.e. according to their general orientation .

We focused on departments containing in their curricula at least one and generally some of the subjects of Table 1.

Table 1. Subject matter from the curricula of the departments relevant to PSE-MST

Bioinstrumentation	Biomechanics.
Biomedical Signals	Biomedical Engineering (Biochemical)
Medical Imaging	Biomedical Engineering (Electrical)
Biomaterials	Biomedical Engineering (Mechanical)
Clinical Engineering	Biotransport
Medical Physics	Biotechnology
Medical Informatics	Rehabilitation Engineering
Medical Electronics	Pre-Medical
Telemedicine	

In order to achieve a complete picture, the departments were then clasified according to their quality.We took into account data concerning the number of students, the duration of studies, the credit point system, the accreditation process, the personnel (full time, permanent, guest professors, external collaborators etc.), the research activities the relevant post–graduate studies and so on..

Collected material, details of the procedure and an extended analysis of data is available as an internal report of PSE-MST. (3)

5. Comparative Presentation of PSE-MST Curriculum.

We present the PSE-MST curriculum (4) in Table 2. PSE-MST qualifies students with two specializations: (A) Medical Instrumentation and (B) Medical Informatics and Telemedicine. The curriculum was formed with the cooperation, in both educational and research matter, of Crete's two largest hospitals: the Regional University Hospital of Heraclion (PEPAGNH) and the Regional Venizelio and Pananio Hospital of Heraclion. The collaboration with doctors and technical-administrative staff includes among others teaching of medical and other courses, student training on hospital laboratories and equipment, development of new products and research projects. The first years' studies mainly used the existing labs of TEI. More labs in cutting-edge technology were developed for Medical Informatics and Telemedicine, a specialization given already to enrolled graduates of other departments.

Graduation requires 5 years of studies and successful attendance of at least fourty courses. Invited speakers, experts in their fields, regularly give lectures and seminars of special interest.

Table 2. PSE-MST Curriculum
(A) Medical Instrumentation (B) Medical Informatics and Telemedicine

Year		Spring Trimester	Summer Trimester	Winter Trimester
1st		• Mathematics I • Material Technology • Physics I • Introduction to Biomedical Technology	• English I • Mathematics II • Physics II • Introduction to Informatics - Operating Systems	• English II • Electrotechnology • Introduction to Electronics • Computer Programming
2nd		• English III • Digital Electronics • Analog Electronics • Technical Drawing	• Technical English I • Microcomputers • Power Electronics & Electrical Motion • Sensors & Computer Peripherals	• Technical English II • Data Bases • Automated Control Systems • Introduction to Telecommunications
3rd		• Computer Networks • Introduction to Anatomy - Histology • Technical Mechanics – Machinework Processing	• Introduction to Biology – Physiology • Hospital Management – Ethics Topics • Bioengineering – Fluid Mechanics	• Medical Informatics I • Medical Optics – Bioelectricity Field Training I (2 months)
4th		• Bio-signal Reception & Processing • Medical Systems Instrumentation I • Hospital Facilitation	• Physics & Instrumentation of Medical Imaging • Digital Communication Networks • Quality Control & Maintenance of Biomedical Equipment	**A** • Biochemistry - Biomaterials • Medical Systems Instrumentation II • Medical Instrumentation Applications **B** • Medical Informatics II • Telemedicine • Medical Image Processing
5th	A	Field Training II (4 months)	• Dynamics & Kinetics of Limbs – Artificial Parts • Medical Systems Instrumentation III • Rehabilitation Engineering	• Robotics in Medicine • Artificial Organs Engineering • Degree Thesis
	B	Field Training II (4 months)	• Artificial Intelligence in Medicine • Biological Systems Simulation • Biostatistics	• Robotics in Medicine • Applications of Medical Informatics • Degree Thesis

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Comparing the contents of Table 1 and Table 2, we see that all the subject matter of the first column of Table 1 is contained in the PSE-MST curriculum. The subjects of the second column of Table 1 do not correspond to courses from PSE-MST, although there are departments containing subjects from both columns.

About fifteen departments have been found with subject maters from column one of Table 1, i.e. common with PSE-MST. For a more detailed comparison with PSE-MST curriculum we chose seven of them. The criteria for the selection are the above mentioned quality criteria. We examined departments from USA and Europe. These departments are.

- Medical Electronics (Herdfordshire University)
- Electronic Engineering with Medical Electronics (University of London)
- Medical Engineering (Bradford University)
- Bioengineering (Arizona University)
- Biomedical Engineering (Iowa University, Miami University, Northwestern University).

The comparison of PSE-MST curriculum with these of the above mentioned depart-

Table 3. Number of common courses between relative departments

	PSE	**Bradford**	**Hertfordshire**	**Arizona**	**Miami**	**Northwestern**	**Iowa**	**London**
PSE		**17**	**12**	**7**	**12**	**12**	**16**	**11**
Bradford (Medical Engineering)	**17**		9	9	12	11	16	4
Hertfordshire (Medical Electronics)	**12**	9		3	6	5	9	6
Arizona (Bioengineering)	**7**	9	3		8	10	7	6
Miami (Biomedical Engineering)	**12**	12	6	8		10	9	5
Northwestern (Biomedical Engineering)	**12**	11	5	10	10		9	6
Iowa (Biomedical Engineering)	**16**	16	9	7	9	9		6
London (Electronic Engineering with Medical Electronics)	**11**	4	6	6	5	6	6	

ments is presented in Table 3. Courses were classified and compared in accordance to the reservations presented in the previous section. Note in Table 3 the number of common courses for the three departments under the name "Biomedical Engineerig", which demonstrates the·above mentioned difficulties and substantiates our procedure.

Comparison proves that PSE-MST curriculum has more similarities to Bradford and Iowa (Bio)Medical Engineering departments but shows common elements with all the other ones.

Common courses (first column and first row of Table 3) are not the same for every case. On the total, approximately eighty per cent of the PSE -MST courses are common to courses of departments of Table 3. The remaining twenty per cent courses, not included in the curricula of the other departments of Table 3, are mainly courses from Telemedicine and Medical Informatics Specialization of PSE-MST, which do exist however among the subject matter of Table 1.

We regard the new department as a program on apar with conventional good quality departments from abroad, with an additional flavour of its own.

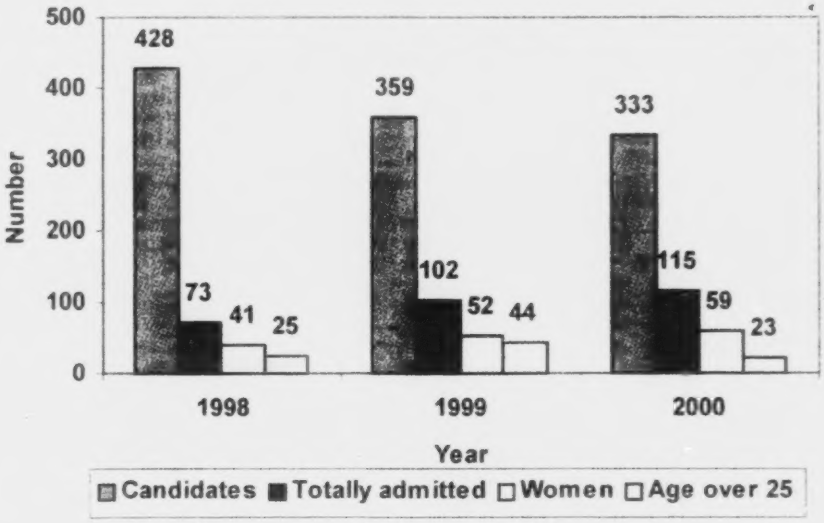
6. First students' statistics.

The first study results of the quality and quantity of students are presented in Figure 1.

From Figure 1 it is obvious that the department is attractive for candidates. The first year of operation of PSE-MST, there were 428 candidates for 73 positions. The ratio "candidates to positions" is approximately 6:1, which is significantly higher than the average in other conventional departments. The interest remains high for the next two years, even gradually decreasing, due mainly to some legal vagueness in the legislation of PSE and some problems to be discussed in the last section of this paper.

Figure 1 also shows that the number of female students is slightly higher than the

Fig. 1. Candidates and admitted students per year



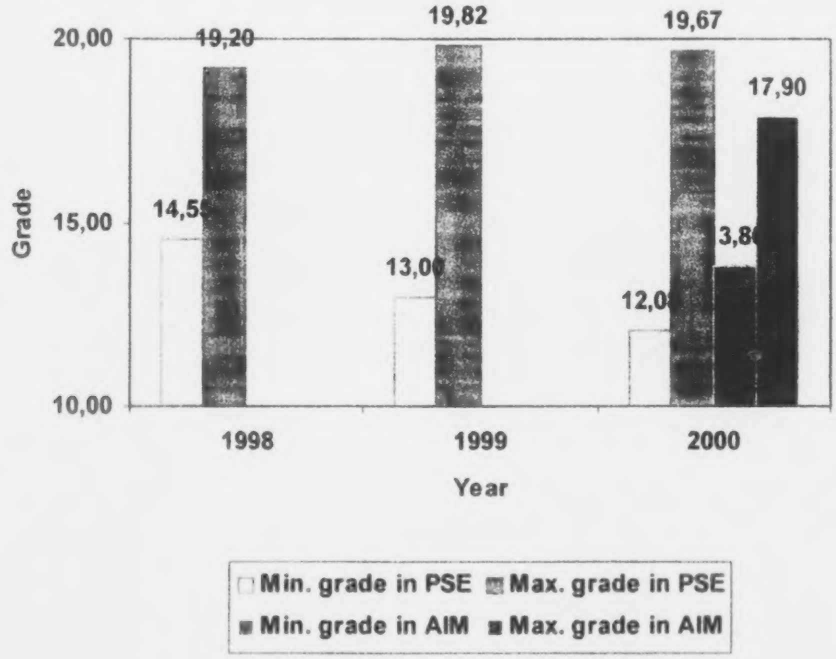
number of the male ones. Approximately one third of the students are older than twenty five years old. The corresponding number in the School of Applied Technology in the TEI of Crete is two per cent, proving that the target of educating older people is actually achieved.

In Figure 2 we present the High School Certificate grades of PSE students for the three years of its operation. For the year 2000 these grades are compared to the grades of students admitted through general entrance examinations in the Department of Applied Informatics and Multimedia (AIM) of the Technological Educational Institute of Crete. Comparison to this particular department has been made because it is a newly established one and its students' grades are higher than usual. Furthermore, the year 2000 not only was the first year of operation of AIM department, but also the first year during which the High School certificate grades were the only criterion for admittance to University and TEI departments, so the comparison was possible.

Better quality of PSE-MST students results further in good performance in their studies, often better than that of students in other departments, as proven by their grades.

Very interesting was the new for the Hellenic Universities experience of the enrollment of students allready granted another University /TEI degree for only the last three semesters of the curriculum. They were admitted only for the Medical Informatics – Telemedicine Specialization (courses labeled with B in Table 2). To this group of students an attestation of succesful attendance was awarded. This project has now finished and a detailed study of the case will be presented soon. Regular students aiming to a degree have not yet attended these courses.

Fig. 2. High school certificate grade (10-20)



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7. PSE-MST Assessment.

Besides the first evaluation and approval by the Ministry of Education, there were also external assessments (5) (6) in two stages of the Department realization. The evaluators examined laboratories on-site, curriculum and course outline, teaching methods, quality of personnel, administrative and secretarial support etc. Questionnaires were tailored to and answered by students and professors. A comparison was made on the Department's aims and scopes and the actual realization. The external assessment results show a contemporary, high quality, fully functional department with good future perspectives.

8. Problems and Future Perspectives.

There were reactions from some student groups and certain TEIs and Universities to the PSE institution because of their singular nature on account of some legal vagueness in their legislation. As a result some of the PSE departments planned were not realised. Those functioning however, exactly because of their new and interesting nature, are considered to be a success. The institution in general requires a complete and detailed assessment. The Hellenic government has already announced the evolution of PSE as part of the now planned Institutes of Life-Long Education. We consider the classroom experience gained from the PSE pilot project, as well as the student response it had, a first step for the successful continuation of new forms of education.

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Tele-Learning: A Prototype System Utilising the New Advanced Technologies in Education

E. Pallis, University of East London
V. Zacharopoulos, Heraklion-Crete, Greece,
A. Kourtis, Institute of Informatics and Telecommunications, Greece
K. Anagnostakis, Heraklion, Crete, Greece
I. Xezonakis, Heraklion, Crete, Greece
G. Gardikis, National Technical University of Athens, Greece
pallis@iit.demokritos.gr, vzachar@techmed.teiher.gr
koutris@iit.demokritos.gr

Abstract: Advances in telecommunication and computer technologies, have enhanced the role of knowledge by converging information and communication technologies towards a more dynamic stage: the *Global Information Society* (GIS). Realising the momentousness of knowledge in the globalise world and becoming aware of the importance of the converged-technologies in GIS, Technological Educational Institute (TEI) of Crete, has adopted a revolutionary way for enabling students to access, and adopt knowledge, any-time from anywhere. This paper describes the architecture of a tele-learning system that enables for distant educational activities, while defining the network configuration that utilises both wired and wireless access. Finally, tests on the system's performance evaluate on the system's QoS.

Key Words: Tele-Learning, Education, Technology convergence, Broadband Networks, QoS

1. Introduction

The Information Revolution, and the Information Age that it engenders, is being defined by an on-going process of economic, social, political and technological globalisation. One critical issue that emerges from all of these restructuring processes is the central role of knowledge that has elevated the Education to the role of a global conscience. The globalisation of economy and its concomitant on the workforce requires a different education that enhances the ability of learners to adopt, and apply knowledge, to think independently and to collaborate with others. Advances in telecommunication and computer sciences, have enhanced the role of knowledge by converging information and communication technologies towards a more dynamic stage: the *Global Information Society* (GIS). Some of these technologies include the Internet, World Wide Web, CD-ROM, and printed, audio, video and other electronic media forms. Converging new advanced information and communication technologies, a new system of education and learning may be applied that will aid the professor and the student in breaking the boundaries of time and space; this is the *Tele-Learning* system.

Realising the momentousness of knowledge in the globalise world and becoming aware of the importance of the converged-technologies in GIS, Applied Information Technology & Multimedia (AITM) department [1,2] at TEI of Crete, has implemented a tele-learning system that enables students to access, and adopt knowledge from any-where any-time. In this context, AITM provides access to archived lectures (in video and audio) and other archived course material that is hosted by a dedicated server, which may be accessed by any student. Moreover, AITM utilises this prototype tele-learning system for providing real-time (non archived) lectures, which can occur with the lecture being at the same location or even at a different place from the student. In this context, current tele-learning applications include students located in several TEI of Crete laboratories connected via cables to the local network and a number of selected students that are connected wirelessly. These wireless students may also be located in the Heraklio downtown utilising the *real-distant student* (given that Line Of Sight conditions exist between their premises and TEI of Crete).

Moreover, AITM has established collaboration with the Institute of Informatics and Telecommunications (IIT) of the National Centre for Scientific Research "Demokritos" for providing real time lectures in the fields of Telecommunications and Information Technology. These lectures are given by professors located at Demokritos premises, while the students are placed at TEI of Crete premises.

In this paper the network architecture and the configuration of the tele-learning system are described, while performance evaluation measurements during a real time tele-training application are presented. Following this introductory section, Section 2 identifies the overall system architecture, Sections 3 and 4 describe in details the configuration of the network at Demokritos and at TEI of Crete premises respectively, while Section 5 evaluates on the system's performance utilising picture and sound quality measurements. Finally, Section 6 concludes the paper.

2. Overall System Architecture

The overall system architecture (see Figure 1) consists of two core subsystems, namely the *Lecturer* (located at the Demokritos side) and the *Classroom* (located at the AITM telecommunications laboratory side) 400km apart. The communication between the lecture and the classroom is via the GUNET network (the Greek Universities network that features broadband capabilities) and is based on the TCP/IP protocol stack, while using the unicasting delivery method.

The Classroom can serve a number of students, either locally connected to the Classroom (through an Ethernet link), called throughout as *Wired Students*, or geographically distributed (but in a smaller distance, compared to the distance between the Lecture and the Classroom), called throughout as *Wireless Students*. The communication between the classroom and a wireless student is achieved through a wireless LAN access spread spectrum link in the frequency band of 2.4GHz that makes use of IEEE 802.11 standard.

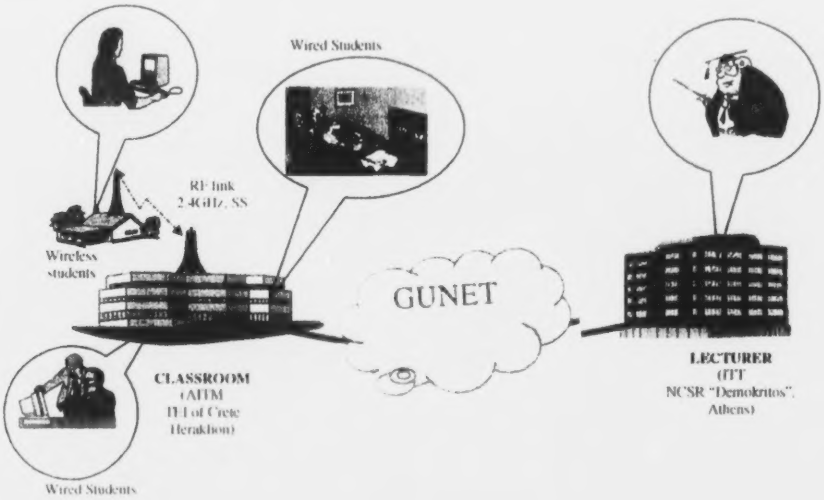
Wired Students
RF link
2.4GHz, SS
Wireless students
GUNET
CLASSROOM
(AITM
TEI of Crete
Heraklion)
LECTURER
(IIT
NCSR "Demokritos",
Athens)
Wired Students

Figure 1 Overall system architecture

3. Configuration of the Lecturer

Figure 2 depicts the configuration of the Lecturer placed at Demokritos premises.

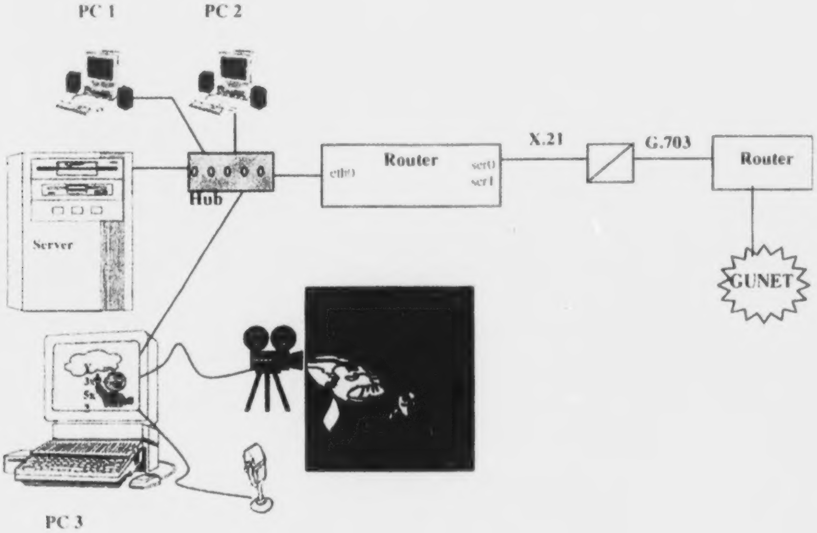
PC 1
PC 2
Hub
Router
eth0
ser0
ser1
X.21
G.703
Router
GUNET
Server
PC 3

Figure 2 Configuration of the Lecturer at Demokritos premises

A multimedia PC, namely PC 3, controls the multimedia devices (e.g. a camera and a microphone), while hosting the appropriate software tool that enables for videoconferencing applications. This software tool utilises the H.323 communication protocol for video and audio transmission, while enabling for file sharing applications (e.g. white board) [3]. Both video and audio data are multiplexed and transmitted over the IP protocol to the Local Area Network (LAN). In the case that the target user (or group of users) is within the LAN, the data are collected by the appropriate PC via its Ethernet card. Otherwise, the data are routed to the appropriate destination via a router/converter chain. The reply signals follow the inverse route back to PC 3.

4. Configuration of the Classroom

Figure 3 depicts the configuration of the Classroom located at TEI of Crete. This configuration describes a Wide Area Network that consists of three nodes namely:

- Room 1 located in Telecommunications Lab (TEI of Crete premises). Several students attend a lecture without using PC stations individually.
- Laboratory 1 located in Computer Room (in TEI of Crete premises). Several students attend the lecture via PC stations that are connected to the local network via cables.
- Laboratory 2 located in the Director of Studies Office (TEI of Crete premises). The director of studies is able to attend the lecture via a PC station that is connected to the local network via a wireless link. This link operates in the Industrial Scientific & Medical (ISM) frequency band while making use of the Spread Spectrum technology. The use of such links enables the provision of tele-learning applications to students that are located far away from TEI of Crete (i.e. in the Heraklio downtown) that realises the real distant student, given that Line Of Sight (LOS) conditions between TEI of Crete and the student's premises exist.

Upon a tele-education application, PC 3 (at Demokritos) establishes a point-to-point communication with PC A, located at TEI of Crete (Room 1). Both PCs host the appropriate software/hardware tools that enable for video-conferencing applications. In this way, the transmitted (by Demokritos' LAN) data are received by a router device (at AITM premises) that collects them from the GUNET (via serial port 0) and passes them to the local area network (through the Ethernet port). Finally, the LAN passes the data to the appropriate destination, which is PC A. Upon the reception of the appropriate video-conferencing data stream, PC A passes the video signals to the output of its video card and the audio signals to the output of its sound card.

Students that are located in Room 1, attend the lecture via a projector device (connected to the output of the PC A's video card) that projects the Lecturer's images on a wall screen, while listening to him/her via a speaker set (connected to the line-out port of the PC A's audio card). Whenever one of these students wants to set a question, he asks it by using the portable microphone or the one that is mounted on a camera that collects and transmits his/her images. These reply video/audio signals are fed onto PC A that forwards them to PC 3 (by utilising the video-conferencing tool).

Students that are located in Lab. 1 and Lab. 2 at TEI of Crete, attend the lecture via individual PC stations running under the MS Windows 98/2000 operating system. In this case, both the video and audio outputs of PC A are also fed onto an MPEG encoder that is hosted by PC B, which runs under the MS Windows NT operating system. Following, PC B (that is also a local server) encodes the incoming video/audio data into MPEG-1 format and produces an IP/Broadcasting stream at the output of its Ethernet card, which broadcasts them onto the TEI of Crete network (point-to-mutlipoint approach). In order to receive, decode and reproduce the MPEG packets, these PCs are equipped with a professional software tool that enables for reception, decryption and reproduction (via the MS Windows Media Player software) of the MPEG stream. This tool enables the student to log onto the appropriate IP/Broadcasting address (i.e. 224.2.127.254), from which the PC will receive the IP packets. Finally, it is the responsibility of the Ethernet card and multimedia software tool's to receive and decode the incoming IP packets and the video/audio cards' responsibility to reproduce them on the screen and the speakers.

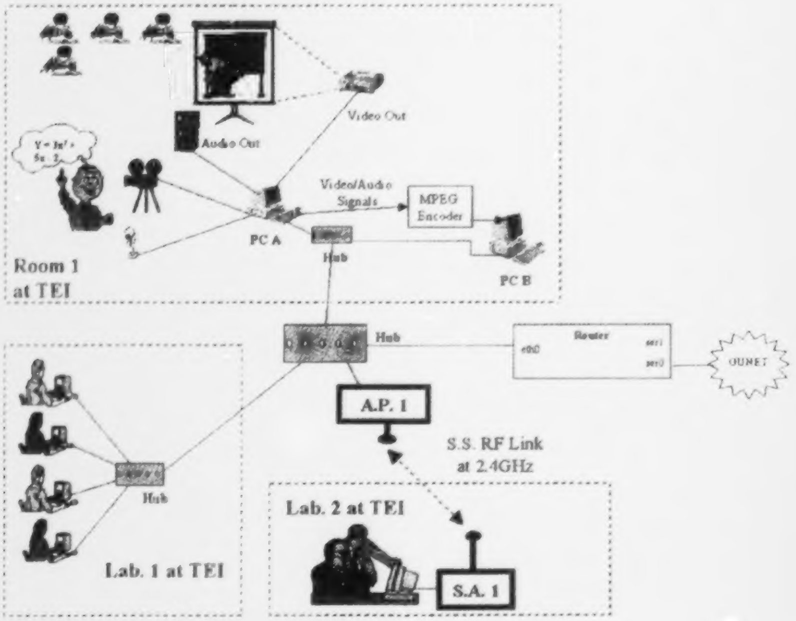

Figure 3 Configuration of the Classroom at TEI of Crete

5. System Evaluation Performance

The performance evaluation of the described system was based on picture and sound quality measurements that were conducted under real-conditions environment, during a real-time tele-education application. As there is no subjective way for evaluating the picture/sound quality [4], a panel of ten people audience was used in order to assess the system's QoS. In this context, the panel assessed on the picture/sound quali-

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ty in respect of both their clarity/clearness and upon the number and the duration of pauses occurred at the end user during a tele-education application [5-7].

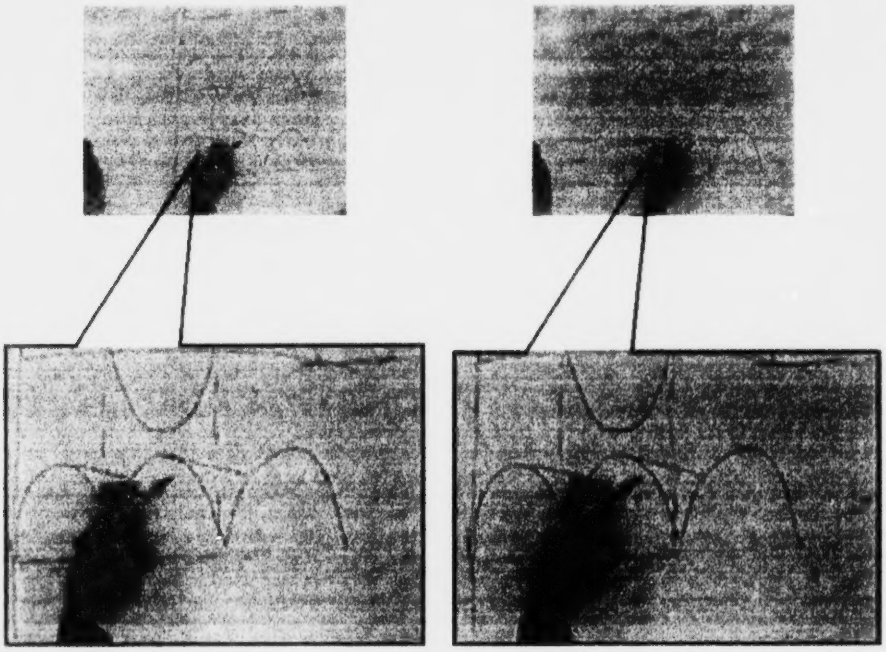
Given that clarity and clearness are factors closely related to the encoding rate of the source signal, tests were conducted on the MPEG encoding procedure taking place at PC B (in Lab. 1 at TEI of Crete). In this context, a series of tests were designed and conducted in order to evaluate the picture quality that MPEG-1 standard can provide. These tests included the encoding of the same analogue video signal into eleven MPEG-1 files, each time with different compression rate.

Table 1 depicts the MPEG-1 files with the corresponding video/audio bit-rates, their file duration and their size. This table also indicates the total MPEG-1 stream bit-rate that is the sum of the video and audio bit-rates plus a 2.15% for the multiplexing overhead packets.

File Name	Stream bit-rate (bps)	Video bit-rate (bps)	Audio bit-rate (bps)	Duration (seconds)	File Size (bits)
File 0	650.000	540.000	96.000	359	233.955.952
File 1	799.600	686.400	96.000	359	287.523.064
File 2	1.000.000	882.400	96.000	360	360.478.696
File.3	1.200.000	1.078.000	96.000	360	432.426.056
File 4	1.350.000	1.224.800	96.000	360	487.028.216
File 5	1.500.000	1.371.600	96.000	360	541.281.560
File 6	1.800.000	1.665.200	96.000	360	649.170.296
File 7	2.000.000	1.860.800	96.000	361	722.012.400
File 8	2.500.000	2.350.000	96.000	360	902.088.088
File 9	3.000.000	2.839.200	96.000	360	1.081.618.056
File 10	4.000.000	3.817.600	96.000	360	1.443.073.912

Table 1 MPEG-1 parameters for 11 files with different compression rate

The spectators watched the 11 MPEG-1 files played back locally on a PC B's screen and expressed their opinion for each one, concerning the picture clarity (clearness) and pleasant viewing. The spectators assessed that for the 4Mbps (stream bit-rate at 4.000.000bps) encoded video the picture quality was very good and the viewing was very pleasant. This was expected as long as the MPEG-1 standard refers to encoding rates up-to 1.5Mbps [8-10]. Consequently, higher bit-rates (i.e. 4Mbps) would provide maximum picture/sound quality. For files with lower bit-rates, such as for the 1Mbps (stream bit-rate at 1.000.000bps), they assessed that the picture quality was not significantly degraded while the viewing was pleasant. An estimate of the picture quality achieved for each encoding stream bit rate is presented in Figure 4.



Picture 1 **Picture 2**

Figure 4 Comparison of picture quality for MPEG-1 encoding rates of 650kbps (Picture1) and 2Mbps (Picture2) played locally at PC B

Figure 4 shows a punctilious comparison of the same frame - during a rapid movement - encoded with 1Mbps (picture 1) and 4Mbps (picture 2) respectively. Comparing the two pictures, it can be observed that the edges of figures in picture 2 are sharper than those in picture 1, while the overall picture quality is not significantly degraded. Concluding, this initial experiment shows that an MPEG-1 video programme with transport stream bit rate equal to 1Mbps can be pleasantly viewed.

However, as long as the provided services are delivered over the Internet and distributed to the students over a TCP/IP protocol based network, the system QoS is related to the available bandwidth of the network [11-13]. Given that the described network utilises both point-to-point and point-to-multipoint delivery methods, a series of network throughput tests were conducted concerning the:

- Wired point-to-multipoint link (from (PC A to PCs in Lab. 1 at TEI of Crete).
- Wireless point-to-multipoint link (from PC A to PC in Lab.2 at TEI of Crete).

The network throughput of the point-to-point link between PC 3 and PC A (Internet connection) was not evaluated as long as there are several bottlenecks between them; consequently the available bandwidth is not guaranteed. Nevertheless, tests conducted in daily base verified that the network throughput varies from about 400kbps up to 1Mbps, depending on the link's traffic at a given time during day. However, the picture sound quality that the assessor accommodated during a videoconference application was quite good even at 400kbps data rate. An estimation of the achieved picture quality at this data is depicted in **Figure 5**.

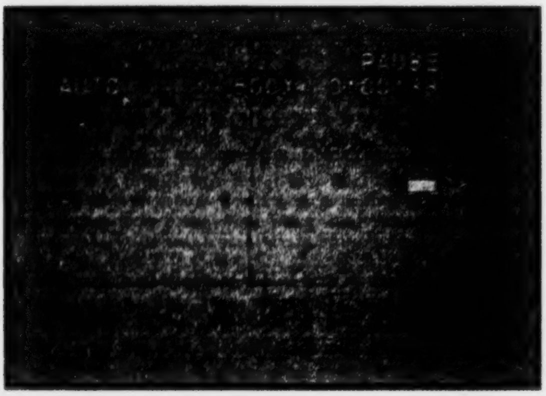


Figure 5 Picture quality achieved during a videoconference application via the GUNET

Figure 6 denotes the network throughput during a file transfer procedure between PC B and a student's PC connected via cables to the TEI of Crete LAN. This figure indicates that the nominal network throughput is about 6Mbps. Same file transfer procedures were conducted in order to evaluate the nominal bandwidth and the available throughput of the other two links. In this context, Figure 7 indicates the throughput of the wireless link between PC B and the PC in Lab. 2 at TEI of Crete that is around 1.5Mbps.

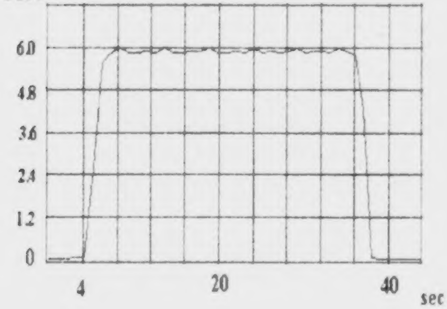


Figure 6 Network throughput for the wired point-to-multipoint link between PC B and the PCs in Lab. 1 at TEI of Crete

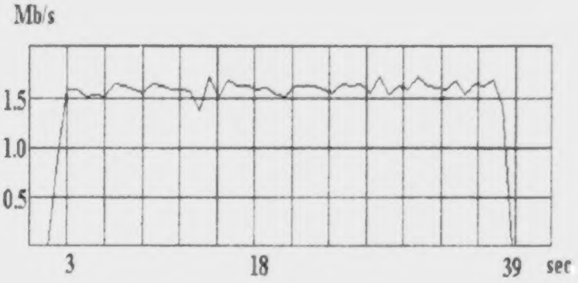


Figure 7 Network throughput for the wireless point-to-multipoint link between PC B and the PC in Lab. 2 at TEI of Crete

These results denote that the useful network throughput is around 6Mbps, unless wireless students want to attend the lecture. In this case the useful network throughput is at 1.5Mbps. Consequently for efficient data transmission, the data rate of the provid-

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ed application should not exceed the useful throughput of the network.

Moreover, given that the IP protocol encapsulates overhead packets during any transmission, it comes that the actual bit-rate of the distributed application is increased by a factor of about 4.8% (due to the overhead packets). In this context, the actual data rate of the distributed application should be at least 4.5% less than the available throughput. For example, in case that the described system utilises the LAN of TEI of Crete with wireless students attending the lecture, the actual data rate should be less than 1.5Mbps - 4.5% = 1.43Mbps.

Figure 8 depicts the actual data rate of an MPEG-1 file with stream bi-rate of 1Mbps when it broadcasted over the TEI of Crete TCP/IP LAN. In this case the actual data rate (average value) is at 130972Bytes/sec = 1047776Mbps (MPEG-1 stream bit-rate at 1Mbps plus 4.5% IP overhead packets).

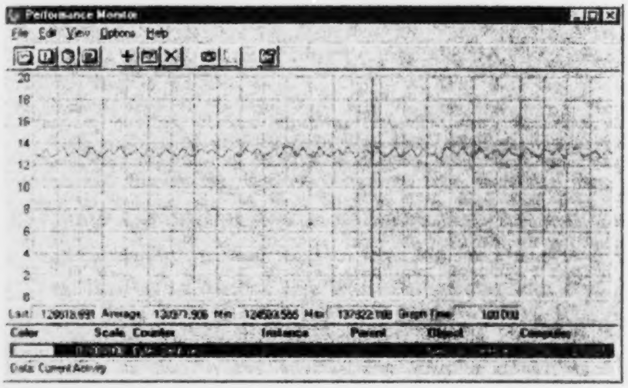
Performance Monitor
File Edit View Options Help
20
18
16
14
12
10
8
6
4
2
0
Last 129018.891 Average 130971.906 Min 124593.565 Max 137922.188 Graph Time 100.000
Color Scale Counter Instance Parent Object Computer
Data: Current Activity

Figure 8 Actual transmission rate (of an MPEG-1 file with stream bit-rate at 1Mbps) Versus Time

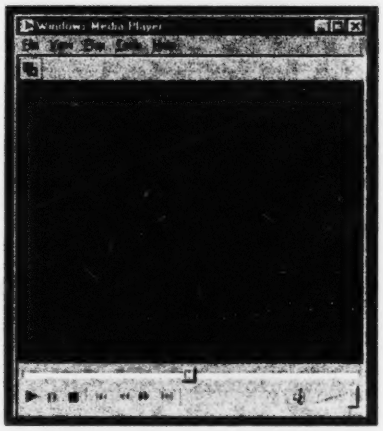
Windows Media Player

Figure 9 Picture quality that a wired student accommodates during a tele-education application

Tests that conducted on the platform for evaluating the system's QoS indeed verified that for actual transmission rates higher than 1.5Mbps (MPEG-1 bit rates higher that 1.4Mbps) the panel of assessors experienced picture and sound delays due to the undelivered in time MPEG-1 packets. The number and the duration of these pauses/delays were proportional to the MPEG-1 data rate. Moreover, the overall picture and sound quality was faded, resulting in unacceptable system's QoS. Results of these tests dictated that broadcasting of MPEG-1 files with stream bit-rate around 1Mbps provides high picture/sound quality and pleasant viewing at both wired and wireless student's PC.

Figure 9 depicts the overall picture quality that a wired user (placed at TEI of Crete) accommodates when a tele-education application with MPEG-1 bit-rate of 1Mbps is active.

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6. Conclusions

This paper presented the overall architecture and evaluated on the performance of a prototype system adopted by the AITM of TEI of Crete that enables for tele-learning applications. The proposed system enables for wired access to the provided services while utilising the real-distant student by enabling for wireless access facilities. Furthermore, the adoption of the IP broadcasting delivery method enables for real-time lectures, while increasing the number of the attending students to a maximum. However, in such a case the level of interactivity between the students and the lecturer is minimum, as long as only a few return channels exist. Tests that conducted on the networking platform verified that the system's QoS can be guaranteed, given that the transmission rate of the delivered media does not exceed the nominal network throughput.

Future work is focused on the adoption of a more sufficient communication method that will enable more students to actively participate in the lecture. Towards this, current research is in the area of developing a software/hardware tool that will enable for multi-conference applications.

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The New Hybrid School Environment: Experiences from the Pilot Use of Communications and IT Technologies by Pupils of Two Primary Schools[1] in Cyprus

Panagiotes Anastasiades, University of Cyprus, Cyprus
panas@ucy.ac.cy, panas@panteion.gr
Agathi Eleftheriou, *elagatha@cytanet.com.cy*
Kostas Xampiaouris, *chanbiao@cylink.com.cy*

ABSTRACT

The introduction of information and communication technologies into education significantly changes the structure and operation of education as it has been until now

The introduction of information and communication technologies into education significantly changes the structure and operation of education as it has been until now. In accordance with the above methodological framework, the pilot introduction of communications and IT technologies into two primary schools in Cyprus will be planned (Elenio Primary School, Nicosia and the 19th Primary School, Limassol, Ayia Fyla. Based on the application of teleconferencing and in the context of the Oikade – Electronic Journeys Home (www.oikade.gr) pilot programme, pupils from both schools will be able to experience new technological applications which will be developed at a pilot level in their day to day life. At the same time, members of the research team will have the opportunity to design, implement and evaluate the basic aspects of the new hybrid learning environment, recording reactions of participants in the procedure, as well as their own experiences as educators and pedagogues. The methodology for the pilot introduction of new applications (teleconferencing, distance learning, tele-cooperation, etc.), the recording of effects on pupils of the school taking part in the programme, and the promotion of the new role of teachers in the new learning environment, will be the main modules in the empirical analysis carried out in the context of the present pilot project.

1. INTRODUCTION

In an era that everything around us is changing at incredibly fast rates, the contemporary human being as well as the social structures that he has built during the ages, are trying to cope with the new demands that are being created.

---

[1] Elenio Primary School, Nicosia, 19th Primary School Limassol, Ayia Fyla.

Indisputably, nowadays we live in the information revolution age, as a result of the rapid development of the new applications of technologies and communications, which pervade almost all parts not only of our professional but also our everyday life.

Computers (P/Cs) are at the peak of technological development, as they constitute the most characteristic advanced party of the new age. The basic relationship between the human being and information is reversed [1]. The information nowadays travels through networks towards people who are looking for it from a fixed geographical point via their personal computer.

The Information Society does not lie in the distant future, we already live in and experience it through a series its applications.

Using e-mail is a first contact with the Information Society.

Surfing the Internet is a first step into that society.

If on the other hand we work, are educated and communicate through networks, then we are in the Information Society (I.S.).

Over the last years the Information Society has been one of the primary issues on the political agenda of the European Commission [2,3].

The education sector is the Information Society's main priority, one of the most important portals of the new digital age [4]. The Information Society is based on the informed citizen, on the person who knows the advantages and the challenges of the new era, as well as the ways with which he will seize the opportunities which will be presented to him [5].

The educational process is presented as the most important tool in the context of transformation towards the Information Society, as its role is to ensure for the citizen all the necessary means in order to manage in a completely different environment, a characteristic feature of which is the continuous effort for creative integration in a rapidly changing world.

The introduction of information and communication technologies into education significantly changes the structure and operation of education as it has been until now

The introduction of information and communication technologies into education significantly changes the structure and operation of education as it has been until now [6]. The basic relationship between educator – learner is reversed [7], as through electronic networks the educational process is transferred to learner's private space, no matter how many kilometres separate the learner from the educator.

The rapid development of new technological communication and information technology applications (teleconferencing, electronic file transfers, etc.), the electronic interconnection of learning units and the penetration of educational multimedia into the basic body of the learning procedure, demonstrate that distance learning as the indisputable pioneer of major and radical changes in the wider educational environment. [8].

Through teleconferencing learners can attend organized units of classes and lectures from anywhere they choose and are able to intervene, to ask questions, to exchange notes, reading lists, etc. With a PC and the necessary multimedia applications, a learner can participate in the educational process, acquire knowledge in which he is interested, evaluate his learning ability or even be evaluated from the distance learning centre which will be able to certify his/her knowledge [9,10].

This living form of the educational process in combination with educational multimedia applications through electronic networks, are quite literally changing the educational map by offering immeasurable possibilities, which up until now were to be found in the realm of desire if not that of fantasy.

The necessity of exploiting the advantages deriving from the application of communication and information technologies, of promoting the social dimension of the educational process and especially, of the widest possible provision of multiple levels of access to learning of persons with special needs, are the building blocks for supporting the new hybrid educational environment.

A hybrid learning environment is one in the context of which we try to combine in the best possible way new technological applications – that set the educational procedure free from its ties in time and space – and the respective pedagogical references to the basis of the traditional educational procedure school of thought [11].

The hybrid learning environment is a conceptual and functional integration of traditional educational methods and new modern approaches.

In accordance with the above methodological framework, the pilot introduction of communications and IT technologies into two primary schools in Cyprus will be planned (Elenio Primary School, Nicosia and the 19th Primary School, Limassol, Ayia Fyla.

Based on the application of teleconferencing and in the context of the Oikade – Electronic Journeys Home (www.oikade.gr) pilot programme, pupils from both schools will be able to experience new technological applications which will be developed at a pilot level in their day to day life.

At the same time, members of the research team will have the opportunity to design, implement and evaluate the basic aspects of the new hybrid learning environment, recording reactions of participants in the procedure, as well as their own experiences as educators and pedagogues.

The methodology for the pilot introduction of new applications (teleconferencing, distance learning, tele-cooperation, etc.), the recording of effects on pupils of the school taking part in the programme, and the promotion of the new role of teachers in the new learning environment, will be the main modules in the empirical analysis carried out in the context of the present study.

2. DESCRIPTION AND OBJECTIVES OF THE PILOT PROGRAM

The development of a pilot plan, in order to achieve open and remote education between two elementary schools in Cyprus, is the heart of a joint effort on the part of the elementary education department of the Ministry of Education in Cyprus, the Department of Computer Science of the University of Cyprus, and the Bank of Cyprus. The students and teachers that will participate in the program will try to be the components of an open learning environment, where concepts as teleteaching, telecooperation and virtual classroom will be put into practical application.

The elementary schools that will take part in the pilot program – Helenio Elementary School of Leukosia and 19th Elementary School of Lemessos (Agia Fyla) – have already considerable experience in the field of teleconference through the Oikade Programme "Electronic Trips Home". The main objective of the Oikade Programme is the development of intellectual and cultural ties between children from schools in Greece, Cyprus and the emigrant Greeks all over the world. It is a vision concentrated on supporting the Greeks abroad in the countries where they live and grow up, thus actively contributing to the maintenance of a communication bridge between those people and Cyprus and Greece. To that end, an electronic Greek planet was created on the web (www.oikade.gr), which uses the technology of teleconference and at the same time aims at bringing the Greek youth abroad closer to their home country.

The great experience of both schools in the area of teleconference will be an important factor in achieving the goals of the pilot program on the open and remote education, as part of which certain scheduled actions will take place.

Concurrently, by making use of the international experience, the program will aim at the development of a specific methodological model of learning procedure, while at the same time great care will be placed on the dissemination of the program's results and the good learning practices that will come up during the program.

The main objective of this pilot endeavor is to gradually familiarize the students with an escalating virtual learning environment, where they will be able, through the methodology applied, to constitute active components of this environment, interacting both with themselves and with their teachers. Furthermore, the experience gained by the teachers and the rest of the people involved will enable them – through the recording of their experiences and the real time handling of potential problems – to work out alternate plans in order to approach this new form of educational procedure (in primary education).

As to the needed equipment, the existent equipment of the two schools will be utilized, which was gotten by means of the Oikade Programme and consists of, per school unit, 6 ISDN lines, 1 Internet line, 1 TV, 1 camera, 1 video, 1 computer and 1 telephone. Technical support is provided by the technicians contracted with the Bank of Cyprus, who should be available to service the program at any time.

3. DEFINING PARTS AND ACTIONS

The entire pilot program will be divided in four main parts, that is part A, which will cover the preliminary period and especially the establishment of the methodology, part B, which will actually be the period of Actions Execution, part C, in which a draft manual of good practices will be worked out, part D, which will concentrate on the Development of Audiovisual material and the creation of a web page. Specifically, the action parts will be as follows:

Part A: Preliminary period

A1: Grouping: The group of the project is formed, consisting of two subgroups, the Project Development and Execution Planning Group, with P. Anastasiades, A. Eleftheriou, K. Habiaouris, and the monitoring group, which consists of the designated representatives of the entities participating in the pilot program.

A2: Planning of actions: The actions are planned and a first timetable of execution is set.

A3: Choosing methodology:

The methodology chosen is that of separating the audience into active and passive. The active audience consists of 6-8 students who sit in a triangle on the top of which we find the teacher and the blackboard. The students of the active audience alternate during the lessons, so that all the students of each class experience the pilot program.

The methodology was chosen as a result of the meeting that was organized by the Department of Computer Science, University of Cyprus, [Available on www.umuc.edu/IDE/modeldata.html], combined with the application of the three models method of Maryland University, USA, and particularly model A [12], that is a large teleclassroom composed of groups of students in two or more distant locations.

The conceptual convergence of model ∞ with the separation of the audience into active and passive groups, forms a transitory approach of original methodology which from now on will be referred to as Transition Methodology, and will be marked by the alternation of active and passive audience as part of model A. Transition methodology ensures equal participation of all the students of the class in the new learning environment, without upsetting the relation of the students to the existing structure of the traditional school schedule, as it should not elude us that the pilot program is implemented during the operation of the two schools.

A4: Equipment Preparation: No further equipment is deemed necessary, since the technological tools of Oikade are going to be used.

A5: Children Selection: The children selected are the Fifth Grade (E΄2) students of Heleneio school and the Sixth Grade (Στ΄...) students of the 19th elementary school of Lemessos, who at the same time are getting familiar with teleconference procedure through the Oikade Programme, realizing the planning of the selected methodological procedure.

A6: Selection of courses for pilot teaching.

The courses selected for pilot teaching are Greek Language and particularly the subjects of national events of 25th March 1821 and 1st of April 1955-59.

Part B: Methodology of Actions Execution

B1: Teleteaching.

B1.1 Description of the Action: The course will be taught by the teacher of Lemessos Elementary School and will be attended by both the students of his class and the students of Heleneio by teleconference.

At a scheduled time the two classes will be ready for action B1. As soon as the teacher is done with his teaching, teleconference is ended and the students of both classes bring up questions and talk on various subjects with the teachers in their conventional classrooms.

Objective of this phase is to familiarize the teachers and students with the concept of teleteaching.

B1.2 Evaluation.

B1.2.1 Students' Evaluation (evaluation of knowledge, experience from the teaching etc.) by the teachers.

B1.2.2 Teachers' Evaluation (noting down problems, ways of solving them, alternate approaches etc.) by the teachers themselves in cooperation with other teachers, specialists etc.

B1.2.3 Evaluation of the procedure.

B1.3 Recording of the evaluation results.

Action B1 is done a second time, with the teachers reversing their roles in order to play the roles of active and passive actionists.

B2: Creation of the Virtual Classroom (Teleteaching – Telecooperation)

B2.1 Description of the Action: The creation of a complete learning environment is attempted in this phase, where the whole lesson period will be covered by teleteaching and where questions from both classrooms will be encouraged. (Discussion –exchange of ideas – other activities). This phase is aiming at the creation of the necessary conditions in order to unfold all the activities that take place in a conventional classroom. Teachers and students familiarize themselves with the idea of the virtual classroom.

B2.2 Evaluation.

B2.2.1 Students' Evaluation (evaluation of knowledge, experience from the teaching etc.) by the teachers.

B2.2.2 Teachers' Evaluation (noting down problems, ways of solving them, alternate approaches etc.) by the teachers themselves in cooperation with other teachers, specialists etc.

B2.2.3 Evaluation of the procedure as a whole.

B2.3 Recording of the evaluation results.

B3: Development of joint activities between teleclassrooms.

B3.1 Description of the Action: In this phase we have an attempt to create an open cooperative environment between the active students of the two classes. Basically, we have an attempt to create a work group that will be in cooperation from a distance, in order to carry through a joint activity.

During this phase, the students are the leading actors in the new cooperative environment, while the teachers play a rather supervising-guiding role, interfering whenever they find it necessary.

B3.2 Evaluation

B3.2.1 Self-evaluation of the students (evaluation of the procedure by the students themselves).

B3.2.2 Students' evaluation by the teachers (noting down problems, ways of solving them, alternate approaches etc.) by the students themselves in cooperation with other students, specialists etc.

B3.2.3 Evaluation of the procedure as a whole.

B3.3 Recording of the evaluation results.

Part C: Compilation of a good practices manual

Indicative Contents

Detailed description of the project's actions

Description of methodologies

Recording of experiences

Homogenization of the evaluation

Formulation of alternate propositions

Part D: Development of Audiovisual material

Audiovisual material will be developed in order to help expand and propagate the whole endeavor. The development of an Internet site will contribute to the creation of an information and communication junction with all those entities and individuals who will have interest in the program.

Finally, here's a brief schedule of the project's execution:

Action part	**2001**											
	1	2	3	4	5	6	7	8	9	10	11	12
E.D A	▨	▨										
E.D B			▨	▨	▨							
E.D C						▨	▨	▨	▨			
E.D D							▨	▨	▨			
E.D E					▨	▨			▨	▨	▨	

4. CONCLUSIONS – FUTURE WORK

It is important that this is the first time in the area of primary education in Cyprus that such an endeavor is attempted, which is marked by three main factors. The first one refers to the morphology of the entities that participated both in the planning and the execution of this pilot program, which clearly shows the great potential realizable through the cooperation of the State and the Public Sector with the University and the Private Sector. The second one refers to the methodological approach of separating the class into active and passive audience – as part of model ∞ – with a constant alternating of these roles by all the students. At this point we should note that the methodology which was chosen is a novel interim–transitory approach, as it ensures the equal and escalating participation of all the students in the new learning environment, without disrupting the relation of the children with the traditional teaching system or the general operation of the school – we should not forget that the pilot is applied during the conventional operation of the two schools. The third factor regarding the pilot program is the fact of its implementation in public elementary schools of Cyprus, which largely ensures the propagation of the results to the entire education community. Concurrently, the evaluation of the whole procedure, the clearest possible delineation of the methodological context of support and, finally, the propagation of the good practices of the program are the future priorities.

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Taking Action and Learning Physics – Research in Secondary School Classes in Two Countries Regarding Experiments and Computer Simulation

Helmut Dahncke and Helga Behrendt, Christian-Albrechts, University, Kiel, Germany

Priit Reiska, University of Educational Sciences, Tallinn, Estonia

dahncke@ewf.uni-kiel.de

1. INTRODUCTION

The subject matter of our project is the relation of learning and taking action. We examine this relation on the basis of important examples from physics lessons which belong to the concept of energy: "The turnover of heat energy in a one-family house", "Energy supply in a dynamic system of different power stations" and "The turnover of electrical energy in the home". The studies carried out on the first two components - involving studies on STS-teaching - have been completed. Our methods of data acquisition comprised concept mapping, taking action as intervention in computer- simulation and the method of thinking aloud. Progress in learning was established through differences in concept maps and in thinking aloud before and after lessons. According to Edelmann (1996) taking action, as we understand it, means that the subject makes a plan and follows it. In addition to this, actions must be elective (i.e. there are alternatives), must be able to be carried out arbitrarily (i.e. actions have a subjective meaning for the person taking action) and to be controlled by a plan which anticipates further action. We use these characteristics as criteria in our study and accordingly regard intervention in computer simulation and carrying out physics experiments as actions.

The findings of extensive research carried out during the last 20 years on alternative conceptions and on phenomena in our natural and technical environment can be interpreted in such a way that structured networks which are created at a very early age and remain consistent through things which are experienced correspond to the students' alternative conceptions; they are networks which are extremely difficult to link to the networks constructed during lessons. This is one of the most important aims of our work group, i.e. drawing up concept maps in the field of energy and energy supply and observing changes which occur during lessons. We describe this as propositionally represented knowledge of science.

In the first two components (A: "The turnover of heat energy in a one-family house" and C: "Energy supply in a dynamic system of different power stations") the problem was "only" having intervention in computer simulation at our disposal. We were aware of the fact that, according to Edelmann, this intervention takes the form of actions, but that it does not have direct repercussions on the subject, and that they are therefore to be regarded as play actions rather than real actions. During our present work (Component B: "The turnover of electrical energy in the home") we have been able to progress further because the turnover of electrical energy in the home also enables our subjects to intervene directly. At present we are therefore essentially dealing with the problem of comparing taking action on computers (intervention in computer simulation) with real actions (carrying out experiments before and after lessons).

Thus we make observations on the subjects' intervention and behavior. In addition to this, we make observations on verbal (oral) statements, since the subjects are requested to explain their intervention. Questions we think are important are whether the subjects fall back on their knowledge of physics, whether they give explanations relating to physics or to other fields, whether they make use of subjective theories (as set down in concept maps, for example), whether they show exploratory, anticipating or reactive behavior in dealing with a dynamic system, and how many times they have to intervene in order to solve the problem and whether this is influenced by different approaches to teaching (STS, traditional physics lessons).

The computer simulations we developed for the field of energy supply required the subjects to solve problems for which a physicist could draw on his knowledge, but would not necessarily be forced to. Observations carried out following the process of thinking aloud make it clear whether the subjects base their actions on their knowledge of physics or whether they use a different approach. In the three project components students are requested to use their knowledge of physics in varying degrees. In component C this request is deliberately smaller than it is in components B and A, in order to be able to examine the presumption that the majority of subjects do not put forward arguments relating to physics of their own accord when thinking aloud, and that they do not do so even if physics lessons have taken place.

2. WORK AND FINDINGS TO DATE

We have drawn a number of conclusions from our findings gained during the acquisition and evaluation of data on subjects in Germany and Estonia.

1. A further simulation was developed in which the explicit postulation of applying physics knowledge in substantiations, i.e. to take action referring to physics, is more pronounced than it is in "The energy supply" in component C. The fact that in the study so far the subjects largely reasoned without referring to physics is hardly surprising against the background of research on concepts from everyday life. Thus we have to establish whether this alters if the explicit postulation of applying physics knowledge is increased during simulation.
2. In our opinion, the relation of learning physics and taking action should basically be of interest. It is therefore unsatisfactory – in the relatively near future at least – if taking action is examined in computer simulations alone in the form of

play actions with occasional subjective sacrifices. This deficit is to be gradually diminished. Our aim is therefore a parallel analysis of taking action in computer simulation and in real life. This can take place, for instance, by choosing a computer simulation which aims at the use of energy in the home and which uses such simple examples for this that observations on taking action in a real situation can be made. A real situation is first and foremost represented by the experiment in physics lessons. Numerous suggestions for lessons in terms of using electrical energy and heat energy in the home sparingly can be found in specialist literature.

3. Our work group is of the opinion that the influence that data collection methods on taking action (computer simulation and experiments) and on knowledge (concept mapping) have on each other is especially worthy of note. Among other things, we expect computer simulation and/or experiments to represent a more intense learning situation than concept mapping, or, in other words, the acquisition of procedural knowledge to encourage declarative knowledge. Our findings so far thus give rise to further questions. In project component C the effect did, in fact, occur as expected in the control class without lessons on the project components; in both experimental classes it did not – except in individual cases. We evaluate this as an indication of the fact that lessons and the knowledge gained during data acquisition before lessons superimposed the desired effect. We have therefore modified the design for further experiments.
4. The effects of lessons which we have shown support the long-criticized notion that traditional physics lessons concentrate too much on putting across physical concepts, principles and theories. In fact, many students state that this is exactly what they find unattractive. Our findings therefore support the frequently quoted postulation – in didactical terms – that lessons should be more application-orientated. The construction of a net of knowledge for the subject of physics is a long and slow process which requires the necessary motivation. In our opinion, teaching physics in a way which contributes to a practical grasp of the subject by actively dealing with physico-technical systems - and which in turn enables students to deal practically with the physico-technical environment - seems to be particularly promising.
5. The preceding paragraph indirectly touches on a restriction which we were basically forced to accept in the course of our study on component C (computer simulation on energy supply). The subjects' intervention in computer simulation which we describe as actions does not have any serious consequences as such concerning this. Although this is moderated in computer simulation by means of several measures, it remains a fundamental restriction. Thus, the important open question remains as to whether our findings on taking action can withstand the real situation.

Within the overall program, the three components A " The turnover of heat energy in a one-family house", B "The turnover of electrical energy in the home" and C "Energy supply in a dynamic system of different power stations" are defined in such a way that the systems gradually become more general and comprehensive. Differences relevant to learning and taking action consist, on the one hand, in the fact that components A and B relate more closely to our direct environment and experiences from everyday life than C. On the other hand, the previous knowledge *pertaining to physics* required for solving the questions in component C is smaller than in B, which in turn is smaller than in A ([C]<[B]<[A]). The same applies to any existing previous prototypal knowledge on the fundamentals of the system. This is lowest in component C and highest in component B. Finally, components A and C only allow taking action to take place as intervention in computer simulation, whereas B, on the other hand, allows this in the real situation *as well.*

Our findings on project components C and A therefore result in the fact that component B was designed as a study after lessons with an STS group (2 classes) and a group without lessons on the project components (2 classes).

3. TAKING ACTION IN COMPUTER SIMULATION AND IN REAL SITUATIONS

In this part of the research project, knowledge and taking action in real experiments and in computer simulation is recorded. Prior to the main study a preliminary study was carried out to test the influence of real experiments and computer simulation on each other. This is primarily a matter of describing the experiments and computer simulation which were used in the preliminary and main studies.

We solve the problem of taking action in real situations step by step. First we deal with experiments during or after lessons. A suitable subtopic of the main topic "Energy" for carrying out real experiments is "Energy in the home". We have developed and carried out several experiments on this topic. Two groups of experiments were selected. In addition to this, a computer simulation was developed comprising the same experiments. Thus we are able to compare the effects of real experiments and simulated experiments.

3.1. The topics of "Lighting" and "Heating water"

During the development of the experiments on "Energy in the home" the following prerequisites were taken as a starting point: The experiments should be able to be performed by 9th-grade students be able to be completed in one lesson, relate to the students' everyday life, be independent of lessons, be suitable for diagnosis, fulfil the safety regulations. Since the turnover of energy in the home is largely heat energy, at least one experiment should be taken from this field. The students (also) have to make decisions in the experiments which can be clearly classified as correct or incorrect in this field

During the given time (45 minutes) the subjects are able to carry out both groups of experiments. From the many experiments developed on a trial basis, two groups were finally selected: "Lighting" and "Heating water". The relevance of "Saving energy" as a topic and its practicability were primarily good reasons for selecting the "Lamp experiment". "Heating water" is one of the few experiments on "Heat energy" which can be carried out in the specified time and with 9th grade students.

The simulated experiments in the simulation are identical to the real experiments in content. The above-mentioned criteria on the technical quality and the practicability are also valid for the computer simulation. Thus, the main criterion in developing the computer simulation was to copy the real experiments as exactly as possible. In order to achieve this, a more or less 3-dimensional work environment was developed under Windows. Most of the photographs of apparatus in the simulation were taken from the real experiments. The computer simulation "Energy in the home" was written using Visual Basic 6.0.

3.2. Content of the experiments and computer simulations

In the computer simulation "Energy in the home" which we have developed, the same experiments are used as those for action in real situations. In the following, the experiments are explained with the aid of two illustrations from the computer simulation. The "Lamp experiment" is displayed in Fig. 1, "Heating water" is displayed in Fig. 2.

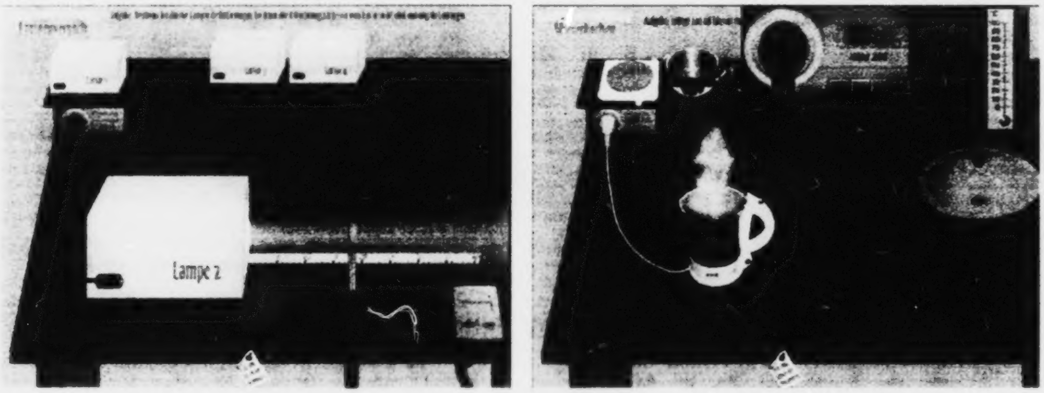

Fig. 1 and 2 Experiments and computer simulation on the topic of "Lighting" and "Heating water"

In the experiments "Lighting" the subjects are to define the power and distances of four lamps at which an illumination of 1000 lux is reached. They have four lamps, a luxmeter, an energy measuring instrument (for power measurement) and a ruler at their disposal. Two of the four lamps are energy-saving lamps and two are ordinary incandescent lamps. They are concealed in wooden boxes (black boxes) so that the subjects are unable to distinguish the lamps by merely looking at them. After measuring has been carried out, the subjects are asked which lamp they would choose for reading and which one they would choose as a night lamp.

In the experiments "Heating water" the subjects are to bring 200 ml of water to the boil using different instruments. In this experiment they have a water boiler, a hotplate, a large and a small pan, a microwave unit, a boiling device, a measuring glass and an energy measuring instrument at their disposal. The students are to bring the water to the boil according to two different criteria: on the one hand using as little energy as possible and on the other hand as fast as possible. Before the subjects start the actual experiments, they are to put the different pieces of apparatus in the correct order comprising five grades. The piece of apparatus most suited to the purpose in question is given Grade 1, and the one worst suited is given Grade 5. The subjects only conduct this experiment with the first two instruments. On the one hand, this is due to lack of time, and on the other hand it is due to the fact that we do not use the experiments as a learning situation but in order to make a diagnosis.

The students are given a worksheet for every experiment to note down their measurement results. They are requested to "think aloud". The interviewer makes a protocol of the subjects' statements.

4. SUPPOSITIONS AND RESEARCH DESIGN

The suppositions that are to be studied within project component B ("The turnover of electrical energy in the home") are:

1. Taking action in the real situation and in computer simulation essentially stem from lessons. (Comparison of the STS-group and the control group)
2. The concept mapping results also stem from the effect of lessons (STS group and control group in Phase 1, see Fig. 3).
3. The actions in the real situation and in computer simulation are learning situations. (Comparison of concept maps before and after action. We expect taking action in a real situation to lead to greater progress in learning than taking action in computer simulation).
4. Knowledge of physics (as acquired in the concept maps in Phase 1) furthers the process of taking action both in real situations (experiments) and in computer simulation, although with varying degrees of intensity. (We expect furtherance to be stronger in the real situation).
5. The learning situations according to substantiation 3 interfere so strongly with each other that they cannot be used on the same subject (supposition of contamination).

(This "mutual contamination" of the survey was to be studied in the first part of component B. In the middle section of the main study we have to work with separate part populations for taking action in real situations and/or taking action in computer simulation. Evaluation is then to be carried out later on with parallelized groups of subjects of the two part populations).

These substantiations give rise to our research design in two stages. The pilot study on the suppositions of contamination (see paragraph 5 above) and the main study (Fig. 3). The pilot study was carried out in the 9th grade of a secondary school. The aim of the pilot study was the examination of the suppositions of contamination, i.e. to establish whether the order of computer simulation and real experiments has an effect on knowledge acquired in concept mapping and whether the two methods influence each other. We collected data on declarative knowledge before and after taking action using the data collection method of concept mapping. After the first concept mapping a parallelization process was carried out in order to obtain two groups of subjects with approximately the same prerequisites. In these parallelized groups we carried out separate studies on the two different orders of taking action and the concluding process of concept mapping.

The results of our pilot study (in key words) are:

The results of the concept mapping show an increase in declarative knowledge after taking action, both in the order experiment – simulation and the order simulation – experiment. Thus, the influence of real experiments and computer simulation on each other which we presumed was not substantiated under these circumstances of the pilot study.

Nevertheless, in the main study we still keep to the designated separation of the two

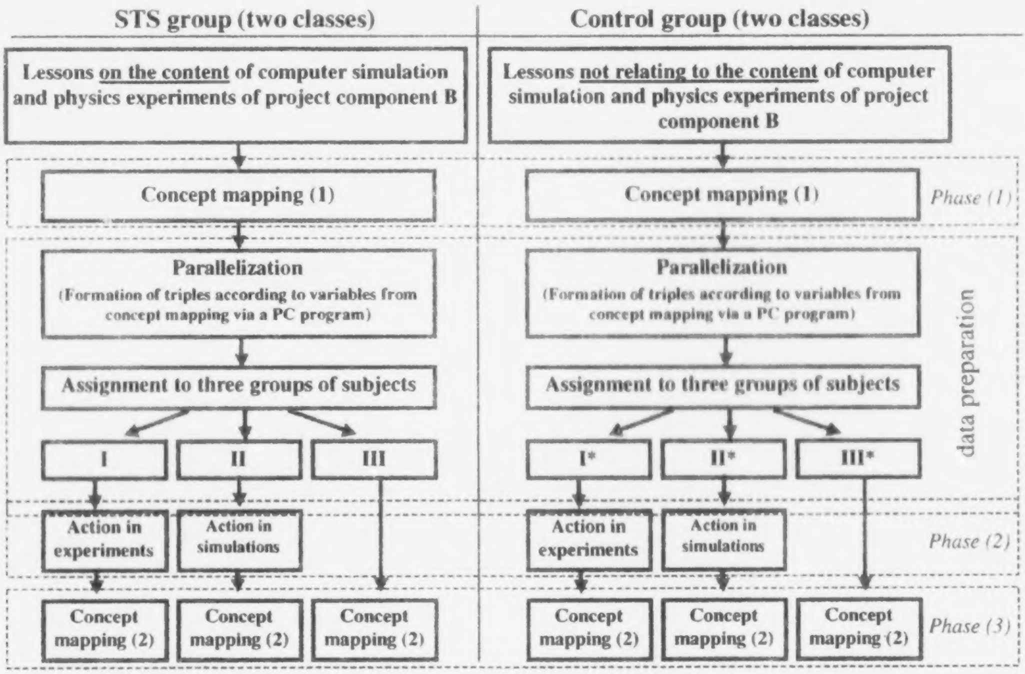
STS group (two classes)
Control group (two classes)
Lessons on the content of computer simulation and physics experiments of project component B
Lessons not relating to the content of computer simulation and physics experiments of project component B
Concept mapping (1)
Concept mapping (1)
Phase (1)
Parallelization (Formation of triples according to variables from concept mapping via a PC program)
Parallelization (Formation of triples according to variables from concept mapping via a PC program)
data preparation
Assignment to three groups of subjects
Assignment to three groups of subjects
I
II
III
I*
II*
III*
Action in experiments
Action in simulations
Action in experiments
Action in simulations
Phase (2)
Concept mapping (2)
Concept mapping (2)
Concept mapping (2)
Concept mapping (2)
Concept mapping (2)
Concept mapping (2)
Phase (3)

Fig. 3. Design of the main study for the STS group after STS teaching and for the control group after lessons without reference to the content of project component B

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data collection methods on taking action. We carry out the studies on taking action with separate (parallelized) groups of subjects only in computer simulations or only in experiments. Among other things, this is done because in the main study lessons take place prior to the data collection (see Design, Fig. 3).

5. EXAMPLES OF THE RESULTS AND CONCLUSIONS

Data collection during the main study was carried out in November and December 2000 in 9th grade classes of a large school. At present we have data on 100 subjects from observations during lessons, two stages of concept mapping (Phase 1 and Phase 3 of the design, see Fig. 3), taking action during the experiment and in simulation, as well as from the records on thinking aloud.

Processing and evaluating such a great amount of data is only possible by computer. We use a number of evaluation programs which we have developed ourselves and in addition to this, we use SPSS; in particular we carry out a multivariate analysis (MANOVA procedure). Further information on this can be found in Dahncke, Behrendt, Reiska (2001).

Evaluation and interpretation have not been completely finalized at the time of going to press. We therefore confine ourselves in this paper to the examples on suppositions (1), (2) and (3):

1. Taking action in the real situation and in computer simulation essentially stem from lessons.

We compare STS groups and control groups (I to I* and II to II*) in Phase 2 (see Fig. 3). The results confirm that both types of taking action depend on teaching before action. In action requiring physics knowledge this shows more clearly than in those only requiring day by day experience. It also shows more in computer simulation than in experiment.

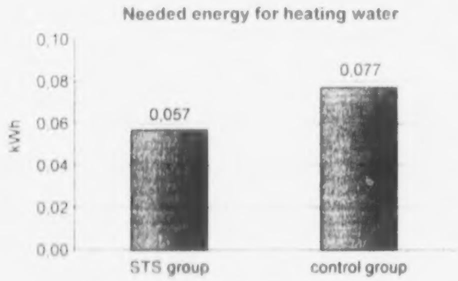

Fig. 4 Computer simulation: The subjects of STS group need less Energy for heating water than those of the control group.

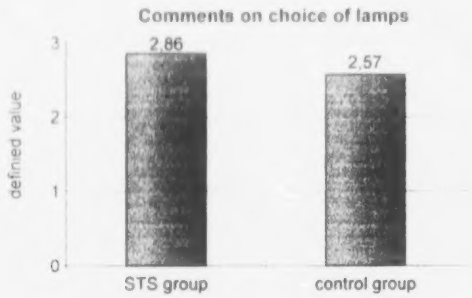

Fig. 5 Experiment: The subjects of STS group give more and better physics comments on the choice of lamps than those of the control group.

2. The concept mapping results also stem from the effect of lessons

We compare STS group I+II+III and control group I* + II* + III* in Phase 1, see Fig. 3.

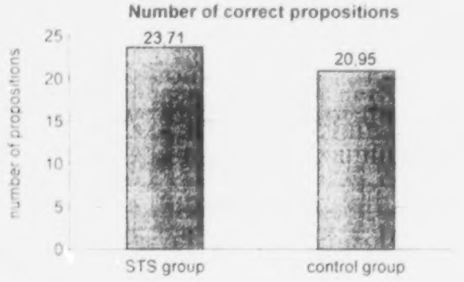

Fig. 6 Variable: Number of correct propositions.

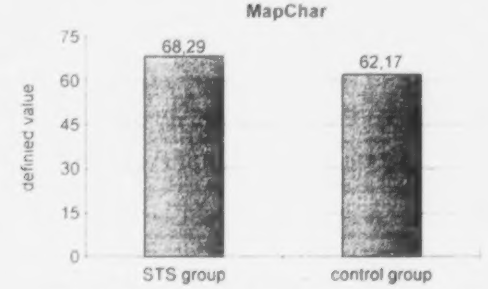

Fig. 7 Variable: MapChar (combined variable of extension, correctness and structure of concept maps).

3. Actions in the real situation and in computer simulation are learning situations

We compare the concept maps before and after taking action both in the STS group and in the control group (I to I*, II to II*, III to III* / Phase 1 versus Phase 3 of the design).

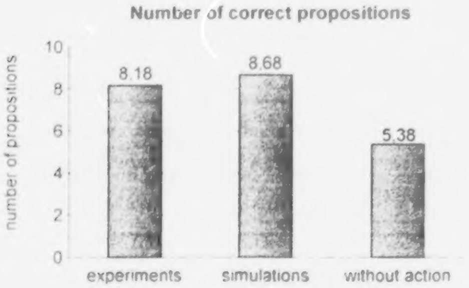

Fig. 8 Increase in correct propositions: Concept mapping before and after experiment and computer simulation.

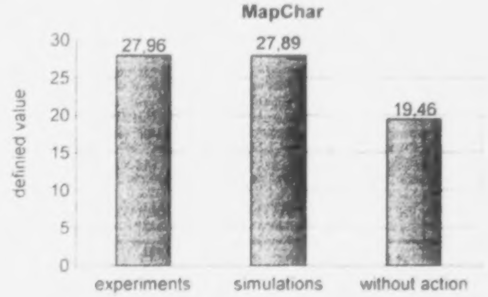

Fig. 9 Increase in variable MapChar: Concept mapping before and after experiment and computer simulation.

A lot of other diagrams too show confirmation of the suppositions 1, 2 and 3. Our combination of teaching and taking action leads to better knowledge than in control classes. The complete results will be available soon and be given at conference.

The effects of teaching we demonstrated support the criticism of traditional physics teaching raised for a long time, saying that it concentrates too much on procuring of physical terms, principles and theories. Many pupils state that especially this is not attractive for them. Therefore, our results support the didactic demand for a more application-oriented teaching that has often been formulated. The construction of a net of knowledge for physics is a lengthy, laborious process that demands the accompanying motivation. Physics teaching contributing through an active approach of physical-technical systems to practical understanding that enables everybody to develop a reasonable approach to the physical-technical world seems to be really promising.

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Bruneian Pre-University Students' Perceptions of Using Computer Software and Internet in Learning Physics

Tan Boon Tee, University of Brunei, Darussalam, Brunei
boontee@mail.ubd.edu.bn

INTRODUCTION

The astoundingly swift advance in semi-conductor knowledge which gave birth to the stunning revolution of computer technology in the last decade has created such tremendous impact on education that practically everyone is caught in a quandary. This highly versatile computer technology is all permeating. It touches almost every aspect of our society and environment. The mushrooming of computer and its widespread use have had such great impact on education especially in science learning and teaching that a major curricular innovation and reform is in order.

Students in Brunei Darussalam have been exposed to computers since the late-eighties, and more and more secondary schools are to be equipped with up-to-date software and hardware to enable students to be computer literate. Since then, there has been gradual increase in the number of teachers (particularly science teachers) using computers to enhance their teaching. Internet is now accessible to many students, especially those who possess computers at home.

In most schools, computers have been used for the following purposes:

(a) To achieve computer literacy which concerns with the general knowledge and basic technical information about computers

(b) To learn simple programming and prepare instructions for computers

(c) To develop skills in designing materials and simulations, and

(d) To practise skills in using and interacting with computer software.

Computerised practice exercises can be effective in reinforcing classroom instructions. The exercises would allow students to move at their own pace and receive immediate feedback. Computer simulations can provide valuable experiences for students without risk and are most useful in science learning where the emphasis is on practical activities and experimental investigations. If properly constructed, these simulations would present life-like situations that allow students to learn through experiential approach essential in the learning of physics.

In this part of the world, there have not been many researches on students' perception of their learning environment in computer-integrated science classroom. Levine and Donitsa-Schmidt (1996) proposed that the integration of computer into science classroom would help to open up new and challenging venues in science education. It had potential in enhancing science learning and understanding, and helping to overcome learning difficulties compared to a traditional classroom set-up. There is evidence to support the fact that computer usage has definite effects on cognitive learning outcomes in science. Other researches revealed that the use of computer simulation and related activities in learning environment which encourage student activity, are more likely to have a positive influence on attitude, and thereby affect students' overall achievement. While investigating the effect of computer on gender difference, Bruner and Bennet (1997) found that early computer experience and gender did affect students' attitude toward using computers. Sewell etc. (1990) argued that the introduction of new tools would mean the emergence of new mind sets in coping with the onslaught of modern computers in practically every field of human endeavour.

In his paper on students' perception and sustainability in using computer as a learning tool, Tan (1999) revealed that the majority of lower secondary students in Brunei Darussalam found learning of science more interesting with the help of computer, provided that the software was appropriate and interactive. There was a strong correlation between boys who were interested in computers and who had computers of their own, and that these boys would continue using computers in years to come.

AIM

Using software and Internet to help learning are getting more and more popular in Bruneian schools. Physics students, in particular, seem to be well connected to computers in gaining new information. The opportunity to access to Internet has allowed these students to open up a new and awesome avenue to learn physics. They can now learn physics not just from textbooks and teachers' lessons, but also from a variety of learning instructions and cognitive development through Internet.

In this respect, it has been widely claimed by teachers and educators alike that computers are capable of doing marvellous things in schools. The computers are not only tools of learning but also serve as excellent resources for learning. Indeed, they just fall short of replacing teachers in the classrooms. With this in mind, the main objectives of this simple research are as follows:

(a) To investigate pre-university students' attitude toward using computer as a learning tool in physics

(b) To examine the extent to which ownership of computer and Internet facility affect students' perception in learning physics

(c) To find out to what extent the availability of appropriate software helps students in learning physics, and

(d) To determine the correlation between students' perception and use of computer.

In conjunction with what have been stated above, the research also attempts to test the hypotheses that the development of the use of computers as tools for learning physics can be further promoted if

(a) the students with positive perception toward computers can sustain their interest in continue using the computers as learning tools;

(b) and that suitable and educative software are readily available to cater for the learning needs of students with varied learning abilities.

METHOD

The original plan was to have a questionnaire administered to as many lower sixth formers as possible in Brunei, and that short interviews were to be conducted on a smaller group chosen at random from the sample immediately after the completion of questionnaire. However, owing to a variety of factors and inconveniences, as well as time constraints, it was not done until weeks later. The interviews were meant to complement the findings of the questionnaire.

The instrument constructed was a 40-item questionnaire. The final year B. Sc. Ed. physics students of the university went through the items and shredded them one by one to determine the feasibility and appropriateness of each of the items. This was to ensure face validity. Subsequently, 8 items were found to be vague and inappropriate and thus deleted.

The revised instrument was a 32 item questionnaire consisting of three domains:

I Interest in computers as learning aid

II Attitude toward using computer as a tool in learning physics

III Use of CD-ROM and Internet in learning physics.

Items 1 to 14 belonged to domain I, 15 to 23 domain II, and 24 to 32 domain III respectively. The questionnaire required students to respond to each item based on a four point Likert-scale (strongly agree, agree, disagree and strongly disagree). A minimum of one point was assigned to strongly disagree, and a maximum of four points to strongly agree.

There were altogether 18 reversed and negative items. These items' scores had been reversed accordingly.

Two of the author's B. Sc. Ed. year 4 physics education students helped to administer the questionnaire and collect the data.

SAMPLE

The sample of 112 students (48 boys and 64 girls) was obtained from two sixth form colleges in Brunei. These were lower six physics students in their later part of the first of two-year pre-university programme. It was a convenient and purposive sample, covering some two-thirds of the entire lower sixth form physics student population in

Brunei. They are among the above average ability groups of their cohorts and most of them would have a good background in mathematics.

RESULTS AND ANALYSIS

The Cronbach alpha reliability index for the instrument was found to be 0.70.

The highest score a respondent would obtain is 4×32 = 128 points, and the lowest is 1×32 = 32. The medium score is 80. Any student who scores more than 80 would be considered as having positive perception of computer software and Internet in learning physics. Indeed 89% of the students scored between 81 and 115 points. The overall mean is 94.32 with a standard deviation of 6.47.

Correlation indices were computed for the three domains as follows:

Domains	*I*	*II*	*III*
I	–	0.49	0.31
II	0.49	–	0.65
III	0.31	0.65	–

A frequency count of the students' responses reveals some interesting statistics:

100% of the students said they enjoyed using computer

98% found computer very interesting

63% had full confidence in using computer

98% agreed that using computer would make them work more efficiently

56% however, would often use computer to play games

45% felt comfortable in using computer as a tool to learn physics

81% thought that CD-ROM and Internet would make physics learning easier

42% needed computer to have quicker access to physics knowledge

80% however, would still rather rely on textbooks to do their assignments.

Some typical comments from the eight students (4 boys and 4 girls) who were interviewed through a non-structured approach are summarised below:

"I like surfing Internet. One drawback is when I want to download something, it would take ages…"

"I am fond of using computer. Sometimes I play games, they can be very exciting. My siblings and I are sharing the only computer at home. I do not get to use the computer as frequently as I wish to……"

"We have two computers at home. They are more powerful yet very much cheaper nowadays. I have access to it all the time. It is fun…"

"The physics web sites can be quite boring. I do not download materials unnecessarily, except when I need those facts that are not obtainable from standard textbooks…"

"I do not quite enjoy the physics software that I either bought myself or borrowed from friends. Though the animation part can be attractive and catching, the explanation is often difficult to follow…"

"The simulation of activities is wonderful. Now and then I would be able to interact a bit. But something seems to be amiss, the simulation cannot be compared to the real experimentation in the school laboratory. I prefer hands-on activities."

It appears that the students in the sample do not depend much on software and Internet to do their projects or assignments. The reasons could be as follows:

(a) There have not been many suitable and relevant software available in the market. Watching the simulated experiments and manipulating with variables may not have made physics learning easier or more interesting when compared to actual experimental experiences in the laboratory.

(b) The materials found in Internet do not cater for different levels of ability of students in physics learning. They are mainly factual and can be very verbose. In fact, for Bruneians whose English is their second or third language, the students would find it hard to read the materials let alone understand them.

The findings reveal that most students possess a positive attitude toward as well as the right perception of using software and Internet in learning physics. Students who own computers at home are far more likely to use Internet and CD-ROM to access to factual knowledge, animated demonstrations and simulated experiments. Boys and girls are equally inclined to use computers for learning physics whenever the need arises. There is a significant correlation ($p < 0.01$) between students' interest in computers and their perception of the benefit of computers as a tool for learning. Furthermore, the correlation between students with positive perception of computers and their frequency of usage of CD-ROM and Internet is highly significant ($p < 0.01$).

IMPLICATIONS AND CONCLUDING REMARKS

The availability of computers in school as well as at home does help to bring about changes in students' learning environment. This simple survey research does demonstrate that students possess a positive perception of the use of computers as learning tools for science, in particular, physics.

The results also suggest that students with computers at home would favour the use of computers for physics learning and that the students understand the important role of computers in learning. This supports the views of Levine and Donitsa-Schmidt (1996).

It implies that a teacher's role is fast changing, from one of rigid transmitter of knowledge to that of a facilitator and leader in the new learning environment. It also highlights the need for student's self-learning and that students must be responsible for their own learning.

Furthermore, the students' positive perception of using computer as an aid in physics learning has been most encouraging, though the actual frequency of use for such purpose leaves much to be desired. This is not just because of the unavailability of good quality software, but also probably due to the lack of interest among teachers in using software and Internet in the laboratory or classroom.

A simple survey of this nature may not be that conclusive. Nevertheless, the author's main concern is, can the following questions be adequately addressed in future:

(a) To what extent would the students be able to sustain their interest in using computer to learn in subsequent years?

(b) To what extent would computer be able to cater for successful and effective learning for different levels of students?

(c) In what ways can computer learning be fruitfully incorporated in science and physics curricula in the near future?

(d) In what ways will educators and info-technologists collaborate to make learning of science more human-centred than computer-centred?

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An Educational Software / Material for Forest Fires Prevention

Sofia Straga, University of Athens, Greece
dimvr@cc.uoa.gr

ABSTRACT

Forest fires are a major problem in Greece (as a part of the Mediterranean basin) faced every summer with destructive consequences.

The confrontation of this problem needs the support of both, decision/policy – makers and society. The role of education is to create society provided with well-educated, active and (environmentally) responsible members.

Concerning to the subject of forest fires, as an educational procedure, which aims at the information delivery and action taking of the students, it is necessary (as a component of this procedure) to define – and calculate – numerical factors, which classificate both: the rate/risk of ignition of a forest fire and the rate/risk of the propagation at the controllable area from the students in order to understand the problem and act properly.

In our educational approach (formed to a learner-centered software/material), the concept is to provide students with opportunities to construct their own understandings trough hands-on, minds-on investigation, applied to a specific (local) field/environment/problem, and to wider requirements as well.

BACKGROUND

Forest fire is the result of a complicated interaction between the human caused factors and the natural forest environment. Their management – prognosis, prevention and behavior- consume a great amount of information. The complexity and the combination of this information provide a dynamic tool to implement defensive infrastructures.

Most of the existing models of forest fire ignition and propagation, according to the international (and the Greek as well) bibliography, have been developed empirically or semi-empirically. Essentially are based on two of the best known, studied and used models. One of them is developed by Rothermel (1972,1983) based on the following parameters: fuel type – proportion of live and dead material –, humidity, wind direction and velocity, topographic factors, slope and attitude (Rothermels' model is implemented as a software package called BEHAVE, P.L Andrews, 1986 for IBM compatibles). The other, is the Byram fire-line intensity model (for a concise summary, see Burgan 1987).

There are more calculation models of fire spread, using additionally wind velocity and slope, as the Canadian Forest fire Behavior Prediction (FBP) system, A.G.Mc Arthur's forest fire danger meter (Weather and grassland fire behavior, 1966). New technology –computational resources– available, suggest new approaches to digital, dynamic systems (Fogelman et al.1987, Tiffoli & Margolus, 1987) which enriched and increased the existing techniques that the Geographic Information Systems' (GIS) modeling capability could offer. Nowadays technological capabilities allow their development according to the constant changes of the information in space and time, widening the limits of choice and the spectrum of interest that the user has, allow the user the visualization of the occurred changes.

METHODOLOGY

In our educational approach, the concept is the requirement of a "frame" within the scientific procedure could be applied –in a simplified way – in order the students:

Clarify the complexity of the wild land fire phenomenon, estimate and calculate the components of fire ignition, reinforce critical and creative thinking through activities based on analysis and evaluation of the disposal information, use mathematical models and compose graphs, diagrams, and curved lines, evaluate an action plan and its' consequences and develop a confident status and a responsible attitude for "environments' shake".

This educational proposal is based on the existing scientific models and information and is applied as an environmental education program/project at a sample of 230 students of the late primary and secondary education.

Part of this project deals with collecting elements/information in order to compose a wildland fire location map (thematic, in digital format) for some specific regions, using the basic principals of GIS, and additionally, a mathematical model. This mathematical model consists of algorithms, which calculate the:

– local factor/index, through fire risk classification areas according to the vegetation type, homogenous influence, and aspect

– the spread factor/index by the influence of the wind and ground slope

– the inflammability index, calculating the meteorological parameters, all adjusted to the Greek conditions, quite simplified to be conceivable to the students.

The collection and registration of the data is taking place on the field, from the students who are equipped with meteorological organs and maps. Then it is entered, stored, manipulated and used, computer aided, (in the lab/classroom) in order to predict a fire occurrence at the study area.

THE MEASUREMENTS/VARIABLES/TYPE OF DATA

The data collected and processed for each study area includes: vegetation/forest species, elevation, slope, aspect, specific climate phenomena, homogenous influence, air temperature, relative humidity, fuel moisture content, wind speed.

In order to understand the phenomenon of forest fires, we describe the basic factors, which compose the environment of a forest fire, influence its occurring and behavior, as components of decision aid.

The basic parameters, which define the fire environment, are classified to climatic, topographic, vegetation types, human caused risk – man factor, or natural causes. These are considered as time permanent or changeable.

The vegetation/fuel factor is rather permanent. The vegetation/fuel consists of the forest species, brush and grass, their loading, continuity and distribution, moisture content of living or dead material, because each of them creates different vegetation communities of different inflammability.

The climatic variables/weather, which influent the moister content of fuels (and the speed of the fire's spread) are considered as changeable in time, season, day, hour, even minute.

The topography, the most static factor, includes such elements as slope, aspect, elevation, and configuration or "lay of the land". The elevation and the different slopes play a great role in determining the fire occur and behavior (fires burn more rapidly uphill than downhill because the fuels above the fire are brought into closer contact with the upward moving flames). As for the aspect (the direction a slope is facing), its exposure in relation to the sun determines the amount of heating it gets from the sun and therefor the amount, condition (moisture, load) and type of the fuel.

The fuels (any combustible material) remain for a long time the same and their development process is rather slow. That allows their registration and classification to the type, size and shape, continuity and the load per surface unit. An exception to their long lasting changing time could be forest management practices (timber harvesting, surface cleaning). The wild land fuels are basically live or dead. The moisture content in their biomass determines the flammability of the dry fuel, due to the changes of relative humidity and air temperature.

To this particular approach, we focus on the dead fuel type (dry grass, shrubs, timber remains) and the moister content measure. The fire risk methods accept as fuel, the ground dead material – branches with diameter 7,5 cm and leaves –, and the alive bushes – branches of diameter 0,5 cm and foliage.

The most changing and unpredictable factor of the forest fire environment is the weather conditions. The weather elements, related to fire ignition and behavior are concentrated to the following: air temperature, relative humidity, sun radiation, cloudiness, and precipitation. During the day, both temperature and humidity vary. Temperatures' raising, lowers the relative humidity and increases the fuels dryness. Particular weather elements, as wind speed and direction and the vertical movement of the air masses in the athmosphear, influence the fire behavior/propagation. The air temperature corresponds each time to specific relative humidity, which in consequence affects the fuel moisture content, during the day. Low humidity takes moisture from the fuels. Both, the air temperature and relative humidity, change during the day. This quota is inverted proportional to the risk estimation; their synergy depends on the increase of the temperature and the decrease of the relative humidity. The moisture content of the fuel is the major parameter of fire ignition. The dryer it is, the more inflammable. The wind velocity and direction influences directly the fire spread as oxygen supply– requisite for the combustion and indirectly the fire ignition, speeding up the evaporation of the fuel moisture.

MODEL IMPLEMENTATION

The local factor/index

The synthesis of this calculation model is based on Chuviecos' FIRE HAZARD model (1989) carried out at the Portuguese National Center for Geographic Information and a GIS, in order to classify the fire risk areas according to the vegetation type, homogenous influence, slope and aspect, slightly changed, adapted to the Greek region, using the prelevant data.

The Chuvieco model/equation :

$$\begin{aligned} P= {} & 0.100\,AVI + 0.046\,AVII + 0.022\,AVIII + 0.010\,AVIV + \\ & 0.004\,AAI + 0.010\,AAII + 0.024\,AAIII + \\ & 0.156\,VF.I + 0.094\,VF.II + 0.078\,VF.III + 0.062\,VF.IV + \\ & 0.047\,VF.V + 0.039\,VF.VI + 0.000\,VF.VII + \\ & 0.004\,DI + 0.014\,DII + 0.027\,DIII + 0.082\,DIV + 0.123\,DV + \\ & 0.004\,EI + 0.007\,EII + 0.034\,EIII + 0.014\,EIV \end{aligned}$$

where: AV:distance to roads variables (as a homogenetic influence), AA:distance to rivers variable, VF:vegetation/forest species variable, D:slopes variable, E:aspect variable, and I, …..,VII the subclasses of each variable.

The forest spaces/vegetation, are classified according to each fire risk coefficient, defined by the Greek studies about forest fires – average, number and burned area of forests, shrubs and grasslands, D. Kailidis, (Forest Fires) and the inflammability coefficients presented from P.X. Munoz (Manual de Prediccion del Peligro de Incendios Forestales, 1982). These two forest species classifications have similarities at the used/controlled case/area studies. The coefficients were also obtained to the BEHAVE Fire Propagation Model.

The spread factor/index

The excising empirical, experimental and experimental information (BEHAVE model and the FBP system) registers the influence of wind variable to the forest fires, additionally to the heat radiation transfer from the fire front to the unburned fuels (head fires). If the heat transfer, caused by the wind, is aided by the slope (angle changing), the rate of spread increases. We could assume that these two factors have generally additional/incorporation character, with various corporations, according to specific conditions – fire frond and direction, upslope or downslope fire direction, the parallel of wind, slope and propagation, the absence of wind or slope etc.

We adapt this general character of addition to our educational proposal.

THE INFLAMMABILITY INDEX

The calculation of the inflammability index of the variable meteorological parameters is based on R. Szczygiel model/formula. The intervals of parameters values are slightly widened to be compatible to the Greek conditions (refereed to D. Kailidis studies about the relationship of the meteorological parameters to the occurrence of actual forest fires, rural combustion of pine litter and the relation of air temperature, relative humidity and wind, to shrubs and grasslands fires in Greek areas).

R. Szczygiel model/formula

R=(ktp+kwp;_kws Where: R:the risk of fire hazard, ktp:coefficient resulting from actual or predicted value of air temperature, kwp:coefficient resulting from actual or predicted value of relative humidity of the air, kws:coefficient resulting from actual or predicted moisture of pine litter

The intervals of parameters values:

Air temperature: ≤ 13,8C° (coefficient 2), 13,9C°–22,3C° (coef. 3), ≥ 22,4C° (coef. 4

Relative humidity: ≥ 69% (coefficient 2), 68%–47% (coefficient 3), ≤ 46% (coefficient 4)

Moisture of the forest litter: >27% (coef. 0), 21%–27% (coef. 4), 11%–20% (coef. 6) and ≤ 11% (coef. 10).

The air temperature is measured in the morning 8.00 am, while the predicted temperature is determined from the meteorological forecast for a given day. The relative humidity of the air and the litter moisture is measured in the morning.

THE PROPOSED EDUCATIONAL MODEL FOR THE CALCULATION OF THE INFLAMMABILITY RATES

Three rates of calculation the fire occurrence and propagation are formulated.

One of them is refereed as **Local Rate** (Rloc) and depends on the permanent/constant factors of topography and the human caused influences. The second one –**Rate of spread** (Rs), depends on wind and slope, the third – **Inflammability rate** (Rinf), depends on the variable components of weather.

The synthesis of these rates, mainly help the student to collect the data, to understand the interaction and the complex interrelationships of the fire environment, and use a calculation version – risk of fire hazard– of the components, which consist the forest fire occurrence (and propagation), conditions.

A.The local rate/index

i.Forest species

Variable classification/7 classes	*Values*
1. shrubland/bushland	32
2. pinus halepensis	20
3. pinus brutia (underwood shrubs)	16
4. pinus brutia (underwood pinus litter)	12
5. querqcus	10
6. pinus nigra	6
7. spruce, apies, fagus sylvestris	0

ii. Homogenous influence/accessibility of the area

1. Distance to roads (railroads, main roads, secondary roads, municipal roads (highly accessible to human activities-camping, excursion)
2. Commerciality of the area (grazing, land use – building activity, previous fires)
3. Distance to waste dumps
4. Irregular and belligerent periods (elections)
5. Distance to installation and machinery (electric company, explosions of artillery shells)
6. No influence.

The climax/coefficient of the risk is between 48 to 0, estimated according to the importance of the influence.

iii. Special climatic conditions

These conditions are refereed to some phenomena usually and periodically appear in some regions (local or seasonal/etesian winds, SW winds-livas, sea breeze, or often thunders). The ranking of these interval values in this case is around 0 to 12, estimated by the student's team.

iv. Aspect

Variables	*units*	*symbol*	*values*
1. Slopes facing North	315°–45°	°	0
2. Slopes facing West	45°–135°		1
3. Slopes facing East	225°–315°		2
4. Slopes facing South	135°–225°		4

Each value is multiplied to 100, only for educational reasons, in order the final extract to be expressed in percentage.

Thus: Rloc = (vegetation + homogenous influence + special climatic conditions + aspect)

There are five classes of fire risk: low risk, medium-low, medium, medium-high, high risk.

B. The inflammability rate/index

To formulate this index, daily meteorological measurements are demanded: air temperature, relative humidity, and moisture of fuel content. This data is usually collected from fire identification stations and satellite imagery. Due to the limits of this educational project, we installed meteorological cages at the controlled areas, equipped with meteorological organs. The measurements were daily registered (air temperature, relative humidity, moisture fuel content, wind), 8.00 a.m., 12.00, and 6.00 p.m.– during the summer months.

Variable	Units	symbol	Interval of value	
Air temperature	C°	f(t)	0–14	2
			14,1–22,5	3
			22,6–27,5	4
			27,6–	5
Relative humidity	%	f(rh)	0–20	5
			21–47	4
			48–69	3
			70–	2
Moisture of fuel content	%	f(mf)	0–11	10
			12–21	6
			22–32	4
			33–	0

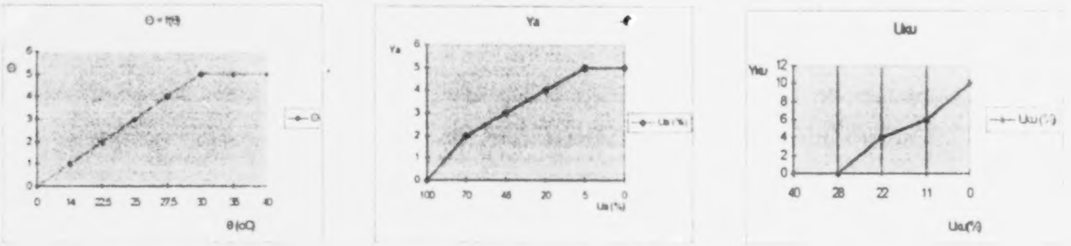
According to the Greek data, the most dangerous intervals of values are: temperature 21C°–35C°, relative humidity 20%–60%, moisture of fuel content below 25%, where the most forest fires are reported.

Then the values form the equation:

Rinf = (ktemp +krh) • kmf

Where: k/coefficient, t/temperatures' interval value from 2 to 5, rh/the relative humidity interval value from 2 to 5, mf/the moisture of fuel content interval values from 0 to10.

The variables diagrams



a. Temperature b. Relative humidity c. Moisture of the fuel content

C. Rate/index of propagation (spread)

In order to determine the fire spread (Rs) we calculate the ground slope and the wind velocity values.

Variable:slope unit:%	symbol:s	value
0%–10%		0
10%–20%		4
20%–30%		9
30%–40%		16
40%–100%		20

Variable:wind unit:BF	Symbol:w	Interval of value
		0–2/20, 2–4/40, 4–6/60, 6–8/80

which are added forming the equation:

Rs = ground slope + wind velocity

When these parameters are added the final (extreme) extraction is 100.

RATE OF DANGER

This rate defines the fire risk as a final calculation. It consists of all the above rates added or/and multiplied. It is formulated as follows:

Rd = R1 + (100–Rloc) _ Rspread / 100

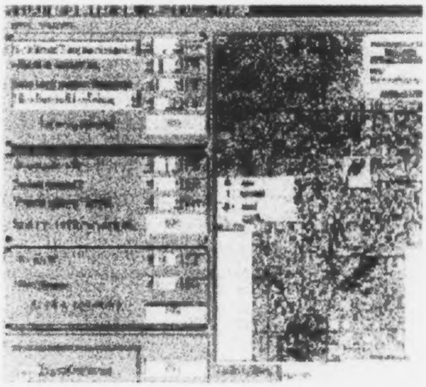
Where: **R1 = Rinflammmability + (100–Rinflammability) • Rloc / 100**

The use of this rate proceeds from the need of the combination of all the measured factors, the total introduction of all values in the (educational proposed) calculation model and the automatic visualization of the result at the relevant thematic map of each controlled area. According to the above rate four risk classes are discriminated.

R>70 high, 69<R<35 medium, 34<R<10 low, R≤ 0 minimum

Outcomes / The presentation of the predictions

Each piece of information/data is entered to the map of the selected area, divided to cells, and stored. The new data possibly concerned to the same cell complicates the existing one, establishing an advanced system of each location's settings or for a set of locations. If the time or space composites are changed, new data is introduced and the cell(s) is/are reconstructed. The total number of these recordings composes a final cartography, in a map version.



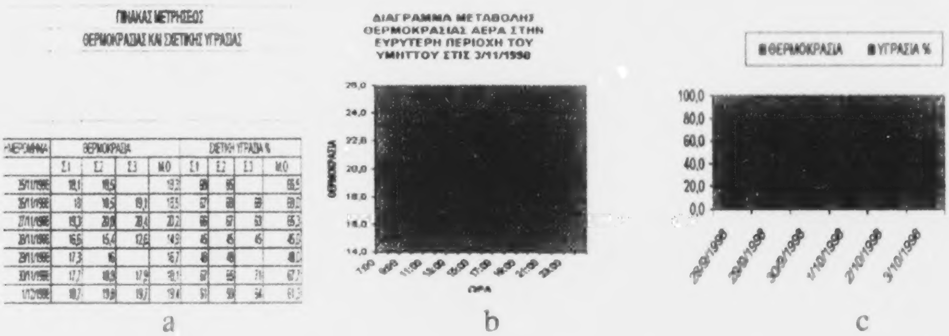
Through the calculation model / algorithm a final numeric result is extracted (danger index) which refers to a specific cell/spot/region of the map and a visual mark is appeared (number, sign, color etc).

The educational benefits – The exploitation from the students

The students are equipped with a tool, which allows developing their abilities, reinforcing expressional skills, through the present "model"; as a contribution to the personal, public, future interest (and/as natures' interest). The orientation is the "problem solving" through the discrimination of the complexity of the environmental problems due to their physical and homogenous dimensions, the conflicts and comparisons of the social factors and also the ascertainment that the solution of a problem it is not always feasible and embrace the concept of active partnership need.

Specifically the general aim of "problem solving" includes profitable procedures for the students in particular cognitive objects. For example to mathematical skills (curve line construction of the meteorological measurements), or to the concept of algorithms (both as a logic and a set of processes of the mathematical calculations, and as the particular classification of each factor) separately or additionally.

An automatic usage and valuation of the measurements is provided, concerned to both; the identification of the problem – practically (e.g. high risk conditions and possible fire ignition), and the sense of the attempt – pedagogically (e.g. the need of the measurements, the concept, the reasoning, the action, the result).



a b c

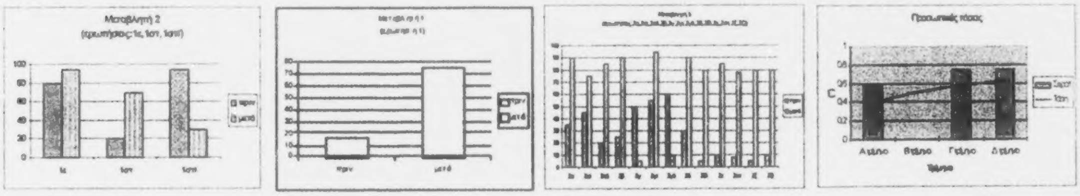
Ex. 2. Temperature measurements (a), temperature change curve line (b), and temperature/humidity diagram (c).

THE EVALUATION

The evaluation in general, is based on six interdisciplinary modules (Hangerford et al. 1985, Hungerford, Peyton, and Wilkie 1978) which provide training in the investigation and action skills, needed by an autonomous and responsible citizen: i. Environmental problem solving, ii. Basics on issue investigation, iii. Using surveys, oppinionairaies, and questionnaires, iv. Interpreting data in environmental investigations, v. Investigating an environmental issue, vi. Environmental action strategies.

THE RESULTS

The general result of this type of evaluation shows a great improvement of all these variables. There is a large number of graphs, concerned the above modules, enhanced by a great number of variables and sub-variables, questions and sub-questions (from pre and post tests given to the students) emanated from these basic modules. There is a measurable change (positive) of the students' attitude, both as a cognitive perception and physical skills, personal trends, concerning the specific subject and the environmental awareness as well.



a b c d

Ex. 3. demo results of Module i, with sub-variables (a), sub-questions (c), primary education (a), secondary (b), trend of improvement (d) blue color is the pre-test results, red is the post-test.

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Knowledge Disseminated by a Popular Science Journal

M. Meshulam, V. Bar, and B. Zinn
Hebrew University of Jerusalem, Israel,
miram@cc.huji.ac.il

Science is very much part of modern everyday life. In democratic societies it is considered of great importance that science be accessible to all the population as all citizens are consumers of science and technology. The mechanism for social diffusion of scientific knowledge has always been popularization through the institutional channel and through the mass media. The contact citizens have with science after finishing formal schooling, that is during most of their lives, comes from the different kinds of popularization means such as television, internet, printed media and science museums.

For the last seven years, the Science Teaching Center at the Hebrew University has been publishing a popular quarterly called "Science 2000". Locally generated articles from top-notch scientists at the frontiers of their fields are edited and simplified by having explanations for the layman added, as well as support from clear graphics. The graphic design is "young" and makes science look "attractive". The journal is distributed to schools, libraries, teachers' centers and sold at subsidized prices to the public.

Popularized scientific information is communicated in its own discourse completely different in purpose, structure, contents and format from the discourse of Science and from the discourse of formal education. It can often characterized as "news you can use", that is new, important and interesting. Each issue of the journal is built around a theme or a metaphor allowing us to explore the way in which the same meta-concept is dealt with in various domains, unlike school science, in which concepts are built hierarchically. When planning these issues, we use lateral thinking and try to transmit this different outlook of multi-disciplinarity to our readers.

Choosing a concept around which to build an issue was always exciting. The editorial board of university scientists, educators, science museum curators and technology experts brainstormed and came up with ideas that would lend themselves to many disciplines. We would explore the widest range of ideas for such a journal, posing many questions and then apply a reality check on available writers, time and money. This would finally outline the journal that was produced.

"Gvulot" is a Hebrew word that has three meanings in English: limits, borders and boundaries. Some of the questions that arose from this concept: How are borders defined? Which borders can move? Are there virtual borders? How important is it to define borders? Can limits be extended? Borders/Limits was chosen as the title for one of our issues. The choice was fruitful as shown when the contents were analyzed by discipline and subject (Table 1). Thus, different knowledge domains are bridged with the meta-concept of Borders/Limits which expands the readers' outlook and allows them to compare and contrast various disciplines.

Table 1.

Discipline	Subject
Multidisciplinary	Introduction to borders and limits
Human Physiology/Art	The visual perception of borderlines: evolutionary origin and application in op-art
Cosmology/History of science	Contemporary and earlier scientists' views on the limit of the cosmos
Mathematics	Limits in mathematics and Zeno's paradox
Space Imaging/Agriculture	Border between Israel and Egypt visible from satellite as an effect of overgrazing
Medical Technology	Extending the limits of accuracy in the operating theater with robots
Psychology	The limits of normative behavior
Entomology	How bees defend their territorial boundaries
Technology/Physiology	Extending the boundaries of senses with technology (report of an exhibition in the Bloomfield Science Museum)
Cell Biology	The cell membrane as a border and a bridge
Sociology/Media	Do virtual communities have borders?
Sport	The changing limit of human capacity in sport over the last century

Other themes explored were *Envelopes, Waves, Faces, Nets, Spheres, Replications, Languages, Structures, Industries, Toys, Aberrations, Trees, Life, Electricity, Senses, Space, Food, Pairs, Keys, Ties, Points of View, Currents, Sun, Time, Illusions, and Survival.*

We monitored the outreach of the journal and its effect on the Israeli educational system and on the reading public. There is positive feedback from readers' questionnaires on the journal's design, readability, interest and its contribution to understanding science as shown in Table 2.

Table 2. Readers feedback about the journal (Likkert scale with 4 as highest)

	1	2	3	4
Design		3%	21%	76%
Increases understanding of science		5%	31%	64%
Readability			24%	76%
Interest			29%	71%

Many of the readers were teachers who noted how they used the journal in their teaching and how they linked articles to the syllabus. Public opinion is also reflected through write-ups in the press and a flow of appreciative letters from students, teachers, and scientists. Some comments are shown in Table 3.

Table 3. Public opinion about the journal

Pupil grade 5	In the journal I read about things I don't learn at school.
Student	I find every issue interesting. I keep learning from the journal.
Teacher	Your work is commendable. I constantly incorporate articles into my classroom teaching.
Teacher	The different viewpoints to the same topic are very enlightening.
Professor Emeritus	It is an important and attractive journal – I am saving them for my grandchildren.
Professor Former president of state of Israel	Your material is enriching and entertaining, written with charm and good taste.
Ma'ariv (Hebrew daily)	I didn't see the first issue and when I saw the second one, I was sorry.
Ha'aretz (Hebrew daily)	If you are looking for a science journal for young readers, this is it!
The Jerusalem Post (English daily)	A colorful, intelligibly written magazine.

Traditionally, the number of each issue sold is counted. We are now seeing a very different way in which the journal's influence is spreading. As we have put key articles on the internet site started by Hebrew University for Israeli pupils, we can monitor the number of visitors to the site. The number is around 3000 a month, a sizeable one in an Israeli setting. Another way of monitoring is through requests from other academic bodies to cite the articles (Table 4).

Table 4. Examples of extended use of the journal by different institutions

High school	AMAL Technological Schools	Science data base; CD ROM
	ORT Technological Schools	Internet sites for science and language
Research Institute	Weizmann Institute of Science	Biology textbooks
University	Hebrew University of Jerusalem	Internet site for high school pupils
	Open University of Israel	Data base for biology students Learning community of science & technology teachers
	Tel Aviv University (College for Management)	Technology reader
Israeli Ministry of Education	Teacher Training Colleges	Text book

Some use them in new science textbooks, others in computerized databases for science teachers and for students of the Open University. Our articles have also been used as texts for the study of the Hebrew language. The journal has an on-going life by being incorporated into new learning materials and has a continuing effect on learning and teaching science in Israel.

Teaching Chemistry with the "Impressive Demonstration-Learning" Method. The "Conventional" Experiments Versus Chemiluminescence Experience.

Lambros Papalambros, 1st High School, Livadia, Greece
papce@liv.forthnet.gr

INTRODUCTION

The synchronous conception in teaching life sciences is the use of real world examples and the process of finding new, applicable, "do able" and safe experiments with materials that every one use in everyday life activities. When the student in secondary education begins the laboratory exercise, in his mind exists the image of laboratories in comic magazines or the images from TV or cinema about " magician" scientist. The teachers that "do science" in their classroom using simple but very comprehensive experiments performed and adapted to fit in the teaching time, make an ineffectual attempt to learning process. Because the visual results of the experiments are in opposition with this that the students expected. The discouragement of students prevents the "creative and expanding classroom". With the expression "creative" classroom I term a classroom with dynamic relation between teacher and students. The discussion of students "drive" the teacher and he/she "learns" to teach answering the students questions. This teaching method is a dynamic relationship. With the expression "expanding classroom" define the expansion of knowledge Expansion of knowledge is effective when the experiments excite the interest of students and give them an impulse to explore, evaluate, create and synthesize. In our effort to change the situation of discouragement and make the "creative and expanding "classroom reality we try to introduce in the methodology "real world examples-real world materials – teaching – learning" the steps "impressive demonstration – exploration-intervention of the teacher with questions into the teaching topic-discussion". The material for impressive demonstrations could be from real world activities or from basic reagents that any one could find in a high school lab. We must overcome the difficulties of materials and make the focal point of the methodology the demonstration. "Doing science" in the laboratory from the students provides students with concrete experiences that do not exist in secondary school students. In our effort to search for impressive experiments and experiments from real world examples we search experiments that demonstrate effectively the firefly phenomenon.Many papers including detailed descriptions of methodology and chemical reactions of chemiluminescence demonstrations have been described. The conclusions of our experiments relied in optical observations. The results are compared with other students, who attended classical lecture of each topic without chemiluminescence demonstrations. Other series of impressive demonstrations are used in our effort to have comparable results between "new" and "traditional" impressive demonstrations. "Traditional" experiments of demonstration are the experiments that are executed with material that exists as basic equipment in most school laboratories. We compared the conventional demonstrations with the "lightstick's" experiments in the following subjects: Safety, impression of students, number of teaching topics, comprehension of teaching topic, time of preparation of the experiment, possibility for classroom activities, exam results.

METHOD-METHODOLOGY-PROCEDURE

During my teaching in high school during the past seven years I have been using many demonstrations that every one can find in many book editions or in the Internet. There are various methods that every one can do in his/her classroom teaching using demo method. In my case, sometimes I execute the procedure while the students observe, sometimes students assist or record data on the board. Sometimes, during the process students have an opportunity to practice being a scientist: they observe, discover, formulate hypotheses, test their hypotheses, create and expand their knowledge.

The demonstrations with the use lightstick were selected because

- It is commercial product, which everybody can meet, in daily activities. There is no need to be seeked in specialized shops of Chemical Products.
- It impresses the students, because they conceive that the fun is connected with the Chemistry lesson
- The experiments with the use of lightstick cover a big part of subjects of chemistry, which are taught in the secondary education.
- The students can have attendance in the implementation of experiments.
- We seek to perform experiments that are in correlation with daily life, i.e. chemical reactions that the students found outside the classroom.
- We seek phenomena that impress also but prove in our students that chemistry is daily, is our life. Thus with the experiments with lightsticks we show in our students that real world (firefly) is chemistry but also the daily activity, fun parks, carnival time, camping, fishing) or emergency, safety life or light extraordinary incidents, is connected direct with the chemistry.

Special treaties of safety are not required at the implementation of experiments with closed lightstick.

We choose the conventional experiments from the laboratory guide that is given in students of secondary education accordingly with the curriculum.

835.

Conventional demonstrations were sought so as:

- To impress the students at proportional manner.
- To use materials that are found easy in a school laboratory.
- The time of presentation of experiments in the students to be small.
- The professor can teach more from one subject of chemistry during the implementation of experiments.
- To be performed in laboratories, which observe strictly the specifications of safety, that imposes the conventional experiments.

The students with the help of professor seek information in the Internet and the bibliography for:

- The toxicity of substances
- Problems and likely accidents that have been presented at the duration of presentation of experiments.

The inquire in the internet gives the information that the students seek. In the continuity the students fix arbitrary units of danger in each demonstration giving price 0 for the smaller degree of danger up to price 100 for the biggest degree of danger.

The degree of danger of each demonstration were measured with criteria:

- The toxicity of chemical substances that react.
- The treaties that are shaped at the duration of implementation of experiment(emission of toxic gases, emission of ablaze, danger of fire)
- The need of storage and treatment of waste.

With base these results the students propose the laboratorial equipment of safety. So they give the price zero (0) in the experiments that require basic safety equipment and price hundred (100) in the experiments that require special treaties of safety.

Using Images and Colors in the laboratory.

It is difficult to evaluate the size of impression that causes the each experiment in the students. The criteria used in an effort are:

- The impressive changes of collocations.
- The impressive changes of pictures.
- The changes that are unexpected.
- The passage from the situation of calm of substances that react in situation of intense reaction and change.
- The cross-correlation with phenomena that they know from daily life activities but can not correlate with the lesson of Chemistry. With base these criteria the students classify the experiments depending on the size of the caused impression and they gives arbitrary prices from 0 up to 100.

EVALUATION OF STUDENT'S PERFORMANCE USING CHEMILUMINESCENCE EXPERIMENTS. COMPARISON OF CHEMILUMINESCENT WITH "CONVENTIONAL" DEMONSTRATIONS.

The evaluation of the student's performance in this new teaching method begins during the demonstration using open questions. I asked them to discuss the experimental approach to the taught subject, to record their observations and develop conclusions. The evaluation results are presented in the table 1.

Table 1. Open Questions Oral Exam Results

Student Group	Number of students	Students passed %
A	180	70
B	160	90

Group A: All of the students in Chemistry Lesson from 1998–2000. The performance of these students in school activities is average or below average.

Group B: All of the students in Chemistry Lesson from 1998–2000. The performance of these students in school activities is above average.

The written examination is prepared with questions on taught topic and the experimental method. The students answered in the following questions:

- Suppose and classify the reaction in the category it belongs.
- Analyze the structure of reactant substances and explain why the reaction is classified in this category.
- Characterize the reaction endothermic or exothermic.
- Combine the quantity of emitting light with the glass vials number that break and so with the quantity of hydrogen peroxide.
- Observe the quantity of carbon dioxide that is produced with the increase of number glass vials that break and make an affair for this.
- Explain the intense emission of light at the beginning of reaction and the progressive reduction of quantity of light with the passage of time,
- Explain the intense emission of light in temperature of seventy degrees and the reduction of emitting light in temperature of zero degrees.
- Using the mechanism of reaction and the experimental results make a conclusion about the order of reaction.
- Classify the reaction nucleophile-electrophile, oxidation-reduction acid- base, or free radical reaction.

The results of writing exams presented in table 2.

Table 2. Written exam results.

Student Group	Number of students	Students Passed
A	180	60%
B	160	85%

Conventional experiments. Afterwards the implementation of experiments and the recording of observations we ask the students answer in the following questions.

- Select the experiment that at the opinion to you fix good the significance of exothermic reaction and you give a definition for it.
- Select the experiment you can study more easily the effect of temperature in the speed of reaction and how you conceive this effect.
- Select the experiment you can study more easily the effect of concentration in the speed of reaction. How you conceive this effect with the concrete experiment?
- Select experiment that helps you to conceive well the relation of quantity reactants and products?
- Select the experiment that fixes the significance of catalysis and tries you give a definition with the use of concrete experiment.
- Select the experiment you could watch the course of reaction and withdraw conclusions with regard to her speed during the time.
- What experiment can accompany the teaching of phenomenon of nucleophilic substitution and hydrolysis of esters.
- What experiment gives color and picture in the activation energy and why?

We ask students to appreciate these experiments depending on the time of preparation and their implementation. The scale of estimate oscillated from the price (0) until price (100). For this estimate the students took into account:

- The instruction time about the experiment
- The time of preparation of experiment
- The time of directives from the teacher to students about safety rules
- The time of activation of safety rules.
- The adaptation of laboratorial time space in the concrete experiments.

The chemiluminescence experiments surpassed the other to the number of teaching topics, in safety when we used only close lightsticks, the time of preparation of the experiment the impression in a dark room and to the fact that these experiments are more fitted for classroom activities. The conventional experiments surpassed on the understanding of the students of exothermic reactions, redox reactions and stoichiometry (limited reactant).

Table 3 summarizes the standardized test results of my students in the years 1995-1998. Students were taught the chemistry topics theoretically with reactions that described the phenomenon and lectures on that topic.

Table 3. Standardized Exam Results (Oral exams)

Student Group	Number of students	Students Passed
A	270	30%
B	200	75%

Table 4. Standardized Exam Results (Write exams)

Student Group	Number of students	Students Passed
A	270	20%
B	200	60%

All the sections from 1995–2000 used the same textbooks, chemical nomenclature, grading scheme and optical mechanical equipment (overhead projector, slides) for classical lecture teaching. There are too many variables that affect the results between students of period 1995–1998 and 1998–2000 (the long time span of data, different way in the presentation of questions on the teaching topic during the exams period). However, the demonstration method for teaching chemical topics appears to have a very positive influence on students under the average and positive influence on students above average. Generally the students who were taught with the demonstration method of chemistry topics performed as well on examinations as students who attended classical lectures. In this lecture the topic is explicitly covered by the teacher but the visual observations, the real world materials, the changes of the color in the demonstration method, makes the taught subject more attractive to the students. The exam results support this opinion.

CONCLUSIONS

The teaching of life science topics in secondary education must perform two functions. The first is the "explication "and the other is the "learning". I talk about learning only when the knowledge maintains its character in "deeper time". This requires the active participation of students. Talking about active participation I am not referring to the experiment related activities only. I refer to activities in the learning process creating the teaching steps. Many teachers spent most of the time writing and looking on the board in front of the classroom. They must learn to spend the same or most of their time looking at the students. Every teacher must look on the face of his/her students when writing chemical equations on the board related the teaching subject. The student's feel that everything that was presented on the board is clear for them but the reality is very different. The only creative process the students perform at this time is the writing of reaction on write book. Teacher has to detect that every classroom has creative mechanism and he must activate it. But the active participation is successful when the teacher can excite the interest of students. This exciting situation requires impressive demonstrations. The impressive demonstrations create an enthusiastic atmosphere in the classroom. I have to explain the expression "enthusiastic atmosphere". "Enthusiastic atmosphere" means exploration, discussion and other demonstrations. The teacher impresses the students, their interest grows and the discussion begins between the teacher and the students. The aim of discussion is the search of answers in the questions that have been created in the students. The students ask and the teacher answer. The students lead the discussion and the teacher follow. The teacher can intervenes also with the suitable questions and directs the students in the instructive objective that it has fixed. The teacher allow the discussion expand in the classroom. With this manner the teacher can reaches the expansion of discussion in all the teaching subjects and so the expansion of knowledge in all the students.

The learner feels like a young scientist and wants to be scientist. Enthusiastic atmosphere means a dynamic relation between teacher and students. In the demonstration -teaching method the dialogue generated about the demonstration phenomenon replaces the teacher as the source of knowledge and the center of activity. This is not a cooperative learning method. But using this method the teacher learns to cooperate with their students, learn to adjust their teaching method to the needs and interests of the students. The role of teacher is to prove to his/her students that the chemistry is a human science like every life science and it requires the human activities that everyone meet in every day real world. Every student must understand that everything around him/her in the world may be chemistry. We don't talk with "chemical words» but the nature and the environment use this language. The demonstration with real world materials or materials that everyone finds in a ill-equipped high school lab, teach many chemical topics and "wake up" forces in the classroom between teacher and student.

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Teacher Training for Better Understanding of the Curriculum in Organic Chemistry

Dace Namsone, University of Latvia, Latvia
namsons@latnet.lv

INTRODUCTION

The system of educational standards was introduced in our country in 1992. Having education standards is one of the peculiarities of Latvia among another postsocialist countries. The goals, content guidelines, student outcomes and the evaluation principles and procedures are determinated by educational standards. The road to attain these standards for students should be prepared by teachers. It means an essentially different situation in comparison with the Soviet period. It has given rise to new problems for our educational system to prepare good standards and to teach teachers about curriculum development. Today the compulsory education reform is under preparation for the year 2005 again. The guiding principles for this education reform are: a changed focus from the acquisition of information to the application and utilisation of information, a practical orientation, accenting functional knowledge and skills, the integration among subjects to avoid overload, duplication and discrepancy (Standards, 1998).

THE CHARACTERISTICS OF THE SITUATION IN THE TEACHER TRAINING

The chemistry teacher is a main actor in the process of changing chemistry education (De Jong, 1995). New standards demand from teachers much more knowledge, professional skills and creativity. It is important to stress the difference between new standards and the system which was functioning during Soviet period when the teacher had to work with only one syllabus, only one textbook for every grade. As a result "only one right approach" how to teach became very widespread between teachers (Namsone, 2000). The freedom for curriculum development, the free choice for textbooks was opened for the teachers with the reform in education in early 1990 ies. It was a very complicated freedom to find the road how to go together with students (to prepare curriculum themselves) without knowledge and practical skills how to do it.

Looking back on the 10 years old history when the system of education was changed but teacher training for adopting changes was not followed as the result a part of teachers got confused. More than one third of teachers want to have back only one syllabus directed from officials (Namsone, 1999). Only 80% teachers (instead of 100% which should be according to the law of education) have nominated the educational standards as the document to plan and organise learning process at school. At the same time more than the one third of teachers are guided by examination materials and tests, the other third (in some regions more than a half) are guided by textbooks, the other third are using syllabus prepared by other colleagues. These data are controversial to the viewpoint by education reform that every teacher will choose this way by himself. The professional growth of teachers was not facilitated but the topicality to do it is clear. One more argument about the actual necessity in teacher training is the tendency to teach more subjects as the teacher himself was taught to do. The differences in teachers base education is high (table 1). A part of teachers during last years are working in the field of three, four sometimes five till nine different subjects (table 2). Not only sciences – health education, computers, languages, handicrafts, mathematics etc. are included on this list of subjects. It is difficult to ask these teachers to be professionals in every subject they are teaching.

Table 1. Education of chemistry teachers in some regions in Latvia

Total number	147	Teachers – graduates of:	
University diploma	146	Pedagogical University	
		of Daugavpils	83
Included:		University of Latvia	
Master of Sciences	11	Faculty of Chemistry	11
Doctor of Sciences	1	Faculty of Biology	12
		University of Agriculture	7
		Riga Technical University	3
		Teacher Training Institutions	
		in Russia (previous SU)	8
		Other	22

Table 2. Number of subjects taught by chemistry teachers in some regions in Latvia

Number of subjects	Teachers (%)
1 (chemistry)	24
2	33
3	27
4	9
5	4
6 and more	3

The stronger emphasis on chemistry subject matter, content and specifical skills which was put forward on chemistry teachers education during Soviet period was not stopped till now. The teachers are more experts in one subject matter (chemistry), but not in practical science teaching skills. Looking at the three dimensions of professional knowledge important to the teacher: content or subject matter knowledge, pedagogical content knowledge and curriculum knowledge (Schulman 1986) we have found that the chemistry knowledge and specifically chemistry skills dominated in teacher training (pre service programs prepared in the faculty of Chemistry University, of Latvia). The education programme allows students to gain the bachelor degree in chemistry (four years). These students can choose one year professional studies in chemistry teaching after chemistry bachelor studies. Therefore students can teach chemistry at secondary level (The students from the faculty of Biology can teach biology on secondary level, chemistry on upper secondary level). Only 0–3% of the faculty of chemistry graduates choose teaching as their career (Cedere, Priksane, Logins 2000).

The training of teachers for many subjects like biology, chemistry, health education, handicrafts etc. (University of Daugavpils) goes away from science teacher professionally to the reality for labour market. Now the graduates from Daugavpils can teach chemistry only on upper secondary level.

The instruction from the Ministry of Education and Science formally declare for every teacher to participate in teacher training for 36 hours during 3 years period. Sometimes it is difficult to realise it in practice for the lack of the training system and trainers. Today there are not professional institutions taking care about in service training of science teacher in Latvia. We can find only few individual activities in the Universities and from the Chemistry teachers' association in this field today. The other direction in in service teacher training is Master studies offered by the University of Latvia, the University of Agriculture, the Pedagogical University of Daugavpils.

The first goal of the new in service chemistry teacher training model prepared by the team of lecturers from the Faculty of Chemistry University, of Latvia, is to help teachers to perfect the chemistry studies content. They try to cover topics of teachers' interest or also the topics, where teachers have experienced some difficulties. The introduction to problem based teaching is added. They give lectures, but the interactive methods are emphasised (Cedere, Priksane, Logins 2000).

Before starting our training programme we prepared the questionnaire to have the information about the teachers participating in our programme. The *students unwillingness for learning* as the main problem for their work was mentioned by a half of participants. Two connected problems are included in this answer from our point of view: the problem of educational standards (curriculum) and the problem of teachers' professionality to motivate students for learning in a real classroom. The information we received from 147 participants corresponds to our hypothesis about the necessity to start the work with curriculum development and contemporary learning strategies for improving chemistry education in our country. Our belief was cemented with 95% responses about the necessity to have new information in teaching methodology.

The way we have chosen for our teacher training programme is different. We found it important to help teachers to be more familiar with educational standards, curriculum development, contemporary approaches in teaching and learning methodology, to give the floor for practical exchange of experience between teachers. We agree with Czech colleagues (Ctrnactova H., Cizkova V., 2000) that the problems in science teaching in secondary schools are partly derived from the understanding of what science education is about, partly from the way future teachers were educated. New teachers and teachers not well experienced tend to teach in the way they themselves were taught.

NEW TEACHER TRAINING MODEL

A lot of in-service and professional development programmes are principally designed to train teachers how to use externally developed syllabus, materials, and methods which are designed by experts and delivered as a package to the teacher (Nunan, 1988, 1996). Models of teacher education which depend on knowledge transmission, or "input-output" models of teacher education, are essentially ineffective. This is because they depend on received knowledge to influence behaviour and do not acknowledge – much less encourage teacher – learners to construct their own versions of teaching (Freeman, 1991, 1996).

The focus of the short in service training courses, where experienced teachers already have well developed mental constructs of teaching should be the teachers' beliefs themselves. … Instead of tutors recommending ready made solutions it should be the participants themselves who, on the basis of their own practice, determine the specific areas of their teaching that they wish to develop (Lamb M.,1996).

An alternative to the top-down "package deal" is to develop the content and methodology through a process of consultation and negotiation with learners. In a related development, the curriculum is being rediscovered, not as a set of prescriptive edicts, but as the documentation and systematisation of classroom practice (Nunan, 1996).

We found it important for teacher training to teach the topics teachers are interested in the way the students would learn as active learners. The active learning strategies are not widely used in our chemistry classrooms till now. The model how to teach teachers as active learners for promoting understanding about standards, curriculum knowledge and developing higher order cognitive skills is being prepared. Our experience is one of the ways how to involve the teachers in practical curriculum development.

The approach engaged teachers in a discussion of their work and could therefore be described as "bottom-up" compared with more traditional "top-down" lecture presentation by a specialist we used for better understanding organic chemistry curriculum.

The word "curriculum" means different things to different people. It is used as wider concept with various dimensions of curriculum practice in this paper. The curriculum development process can be seen as a negotiative process between teacher and students. It differs from traditional approaches to curriculum design where these decisions are made by "outside" experts (Nunan, 1996)

Organic chemistry for upper secondary school is very important for students understanding about the chemistry in our life – we choose to demonstrate our teacher training model. Insufficient practical experience for teachers, curriculum developers and textbook authors brought a lot of problems and misunderstandings for teaching this item till now after more than 50 years not being included in the curriculum for compulsory education. The lack of experience in teaching organic chemistry in basic school was one of the reasons for approximate and superficial formulations for obligatory content in organic chemistry for compulsory educational standards (1992). No successful and controversial expositions followed in different textbooks. It did not help real chemistry teachers in class work. Today it is a very good opportunity to start to change the understanding about teaching content in the light of new standards, new education reform for 2005. The viewpoint has been changed from the curriculum which is taught to teachers in the way it could be developed.

In our teacher training model instead of the classical question: "What to teach and in what order" we suggested to design the workshop aimed at introducing the teachers as learners with organic chemistry curriculum design. The modified workshop has the following steps:

Step 1 The conception, goals and outcomes of our common work

Step 2 The brainstorming in small groups (4–6 colleagues from country schools and gymnasium, both) about the problem – main items from organic chemistry in real life that are important for students' learning

Step 3 The session – common decision making about themes we choose

Step 4 The brainstorming in small groups to prepare students' learning outcomes – what students should know, understand, and are able to do practically (2 groups for each of items)

Step 5 The session – common decision making about students' outcomes

Step 6 The design of strategies, methods, means to be used to achieve these outcomes – the preparing of one lesson as an example in organic chemistry (small groups)

Step 7 The presentation of lessons for colleagues (the students, teacher activities prescribed)

Step 8 The analyses of our co-operation – the results we have, the road we went, why

Step 9 The evaluation of our work

Step 10 The preparing of printed material

Step 11 Corrections after some time

Steps 1 to 9 are realised during the workshop, steps 10 to 11 are used for feedback and improving the prepared material.

RESULTS AND DISCUSSION

The curriculum items prepared by teachers as a result of successful co-operation are given in table 3.

Table 3. Characteristics of issues for organic chemistry

The compulsory chemistry educational standards (1992)	The material prepared by teachers
The notion about organic substances:	
1) organic substances	*1)the variety of organic substances in the human life,*
2) hydrocarbons	*2) the organic substances – the source for fuel energy,*
3) oxygen containing organic substances	*3) organic substances – the resource for food,*
4) carbohydrates, proteins etc. Compounds important for living organisms	*4) organic substances for hygiene and healthy world,*
5) polymers, the important characteristics of plastics	*5) the polymers in everyday life*

The examples of student outcomes prepared by teachers we demonstrated on the theme *"organic substances for hygiene and healthy world"*. The teachers have found important that the students:

– should be oriented in the variety of detergents using instructions and labels,

– should name well known detergents,

– should argue about the problem of pollution effect of detergents to the environment in their village or town, state,

– should be aware of unhealthy influence of etilalcohol to human organism,

– should be aware of reasonable using of medicines and drogs in human life.

The curricular material prepared, as the result of our co-operation is helpful for developing the students' motivation of learning because it is more interesting, locally oriented, practically oriented, more actions included. It is very helpful for breaking the stereotypes in teaching chemistry at basic school.

Trying to improve this model for many (14) times there were some differences in the working process and in the given results. The next time the workshop was offered, some modifications were made. While the workshop was generally well received, there were a number of problems.

The historical heritage with "only one right way" how to teach has deep roots in practical work. It is very important to go out from positions of stereotypes in the first steps. Otherwise the continuous work is problematic as it was in one of our regions because we have curricular items for traditional systematical classification of organic substances after the second step of our model.

The science teachers are not very experienced in active learning strategies. Some of them prefer the lectures as the best source for teacher education. It takes a lot of time and profesionality to work for active learning priorities. The learning environment is very important for teachers learning, too. Old fashion chemistry rooms with screwed to the floor tables at schools were we were forced to work sometimes were not a facilitating environment for a creative generation of new curriculum ideas.

The participants in every training group are the teachers from one region working together for a number of years in different educational activities. In spite of it there are very formal contacts between science teachers in some of regions what is not helpful for successful active learning process. The co-operation between teachers and teachers and trainer is more successful if this model is realised as a part of longer teacher training programme. It is important not only for better psychological contact between the teachers, trainer and teachers, it has given more active learning experience and knowledge about taxonomies of students' educational outcomes before curriculum studies. Professionality of the trainer to guide a fruitful and friendly co-operation of teachers is important, too.

This model has been developed and improved for different curriculum topics with 14 groups of teachers in different regions in our country during the period 1999–2001. Chemistry teachers from one or two regions are the members of every group, the teachers from basic schools and gymnasiums included. As the results of our common work we found:

– the teachers have learnt not only how to teach organic chemistry for compulsory education but they also participate in the active learning process of curriculum development

– the exchange of teachers' practical experience has occurred

– the practical material for improving chemistry educational standards and curriculum in the light of new education reform has been prepared and would be used.

143 teachers in 7 regions were asked to evaluate sessions. In the formal evaluation of the workshop, participants were asked to indicate findings and wastes. The teachers wrote:

– at the end organic chemistry in upper secondary school is clear to me,

– dominant was not the item but the way we had looked at this,

– the more interesting: critical, analytical and our own opportunity to choose the material for chemistry course directed from "top",

– I know what other colleagues are doing,

– the teaching priorities are clear to me after this group work;

– we "were forced" to have practical and creative activities...

– it will be valuable to analyse other themes in such a way

– the approach we discussed was very useful. I had prixes of conscience that I had taught my students well enough, perhaps I worried them too much.

CONCLUSIONS

Today there is the discrepancy between the open freedom of teacher's curriculum and the actual necessity for the training about curriculum development which was not organised till now. The model prepared by us is the first step for better understanding educational standards and curriculum development in chemistry education in our country.

The teacher training for better understanding of the curriculum is important for both – teachers and curriculum developers. The teachers are active participants in the process of developing the curriculum – they learn how to prepare a more students' oriented organic chemistry curriculum, what it means to be actively involved in learning. The curriculum developers have the feedback for improving the educational standards. We learn from each other.

This model should be more successfully realised as a part of longer teacher training programme for giving more active learning experience and knowledge, for better psychological contact between teachers and teachers and trainer.

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TechnoScience 2000+: A Workshop on Innovative Professional Development Materials for a New Millennium.

Don Plimmer, Science Education Consultants, UK

Jane Gamble, ICI, UK

Eric Parkinson, Canterbury Christ Church University College, UK

don@science-education-consultants.co.uk, jane_gamble@ici.com, Efp1@cant.ac.uk

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If there is any one feature that must define the needs of the citizens of the new millennium, 2000+, then it must surely be the necessity to develop an increased understanding and awareness of the role of science and technology in society.

This understanding and awareness has been crystallised in the UNESCO/ICASE Project 2000+ in which the idea of "Scientific and Technological Literacy" has been identified as a key global issue of critical importance.(Holbrook & Rannikmäe, 1997; ICASE, SEAMEO-RECSAM,UNESCO, 2001; UNESCO, 1999.,UNESCO, 1994.)

Science and Technology will be called for increasingly in the future to assist in the development of a universal awareness of the consequences of actions taken by governments, commerce, industry and the individual citizen and to encourage all elements of societies to take responsibility for their actions.

To achieve the rapid improvements in Scientific & Technological Literacy that are so urgently needed to achieve these ends requires a massive investment in the education of the citizenry both in schools and in post-school educational mechanisms.

The lack of teachers at all levels adequately trained and experienced in the fields of science and technology is a problem recognised by most, if not all, countries throughout the World today. Yet without a scientifically and technologically literate and highly motivated teaching force, the aim of improving the Scientific and Technological Literacy of future citizens cannot be achieved.

While improvements in the pre-service education and training of teachers is important, and many important initiatives are currently under way in this area, more immediate results will only be achieved by improvements in professional development of current teachers. Unfortunately, in-service education is universally expensive, especially where it involves taking teachers out of their classrooms for long periods of time.

There is much evidence to suggest that interest in and attitudes to subjects such as science and technology are formed very early on in a child's schooling and thus the role of teachers of these younger children may prove crucial to the success of educational initiatives taken to improve the scientific and technological education of secondary school students.

Research by one of the authors (Plimmer, 1992) has suggested that key factors inhibiting the capability of many primary/elementary school teachers to teach science and technology successfully has been their lack of confidence, frequently coupled with negative attitudes to these subject areas.

In attempting to elucidate reasons for the lack of confidence in their ability to teach science and technology, the research identified lack of knowledge and understanding of scientific and technological principles as a major concern.

However, where negative attitudes to these subject areas persist, traditional in-service programmes were often seen as representing no more than a continuation of the 'boring school science' that had, in many cases, generated the teachers' negative attitudes in the first place.

In order to tackle some of these difficulties a flexible learning programme based around printed materials (Catherall, Plimmer, Nicholls, and Sales,1993) was developed at Canterbury Christ Church University College. Highly successful courses based on this material were conducted in the South of England over a period of ten years during which the achievements and attitudes of teachers undertaking the courses were monitored.

Inter-course and post-course evaluations identified some potential for improvements in order to extend the value of the programme.

In spite of the primarily distance-learning design of the programme teachers still experienced problems with finding time for the, albeit few – three to five per term - tutorials, with travelling to the tutorials, with fitting the in-service programme to the requirements of their particular teaching programme and with matching the programme to their, often very different, prior levels of knowledge and understanding.

In addition, some teachers suggested that, in spite of attempts to write the materials in a more 'user friendly' fashion, the written materials still reminded them to a limited degree of the school textbooks that had contributed to their initially negative attitudes to science and technology. Significantly, at least some of the units were found to be little more stimulating than traditional school textbooks. Furthermore, one word that was noticeable absent from most evaluations was 'interesting'.

These findings prompted the writing of a new series of units under the title *Success with Primary Technology* (Parkinson and Plimmer, 1995) based on ideas derived from work by Munroe and others (Munroe, 1991, Munroe and De Young, 1994), Hidi and

Baird (Hidi and Baird, 1986, 1988) and Shimoda (Shimoda 1993). These researchers had indicated that material written with tighter control over wording and sentence construction together with a more story-based approach should help primary/elementary teachers to find the material more readable.

Further research (Plimmer, 1996) explored in depth the readability and interestingness of both *Success with Primary Science* and *Success with Primary Technology* and compared passages taken from these publications with ones from traditional texts and from scientific stories.

Although the progression from *Success with Primary Science to Success with Primary Technology* indicated some improvement, the essential linearity of the written material still posed problems of curriculum fit and matching to the specific learning needs of individual users. The sequence, and some degree the pace of learning was still determined by the writer rather than the learner.

Furthermore it became clear that the problems of accessibility in terms of time and place could not be solved by a face-to-face tutorial system, nor could such a system adequately allow for individual differences of learning style or pace. Thus an Internet-based solution was sought in which the learner could select a personal, route through the available information and work in a way that they found most appropriate to their own learning style.

TechnoScience 2000+ was thus developed as a package of flexible learning materials designed to provide a resource that could be used by individuals and organisations as part of a programme to help solve the professional development problem. The current materials aim specifically to address issues surrounding the teaching and learning of science and technology in primary/elementary schools.

By working with TechnoScience 2000+ teachers are empowered to extend their background knowledge and understanding of science & technology processes while also gaining an insight into related classroom experiences that may be easily adapted to use with the children they teach.

The Internet-based approach has enabled us to develop material that is far more flexible in use than the written material could ever be as it is designed to provide a personal in-service training program that anyone can use at any time.

It provides both the knowledge base for teaching Science and Technology and help with the application of this knowledge to the classroom

While the primary target audience for the material is in-service teachers of primary/elementary school children – that is, in the age range five to twelve years, the materials are also being used successfully in pre-service and in-service teacher education courses both in the UK and overseas. The open nature and ready availability of the material also make it an ideal vehicle for curriculum developers who can use it as a framework on which to develop programmes appropriate to their own curriculum, language and culture. This has happened in South Africa, is currently under way in Jamaica and Nigeria and further groups are exploring the possibilities in India and the Far East.

There are 4 key features that offer advantages over traditional face-to-face in-service training methods.

I. Flexible learning

II. Web format

III. Classroom based

IV. Industry supported.

The materials are currently available on the World Wide Web at (www.ici.com/ici_schools/) and include, at present, 13 Modules organised into two groups.

- Knowledge Issues modules provide the teacher with the knowledge base needed to teach a wide range of Scientific and Technological content at-an appropriate level.
- Teaching Issues modules give guidance of teaching methods, resources, organisation, assessment etc.

Each module is constructed upon the same basic plan. This consistency means that once the plan is understood working with the material is a user-friendly experience.

A module deals with a particular topic and may contain two to four 'tasks' each of which explores a particular theme. In each 'task' there is an introduction to the topic to set the scene followed by a list of the 'activities' in the task.

All components of a module, including the introduction, contents list and list of tasks are permanently available on a side menu bar, thus allowing access to any topic at any time.

Within a task there are a varying number of 'activities'. The numerical listing of all the 'activities' are constantly shown in a window at the bottom of the page, e.g., 1.1, 1.2 etc. Rolling the mouse pointer over these numbers highlights them and brings up the title. This is an important feature, since it avoids the linearity problem teachers complained of in printed material.

An Activity may be a thinking or doing one. If it is practical a list of resources needed is given first. Resources are listed under the heading 'You will need' and these are always simple, readily available items. Traditional 'science laboratory' items such as Bunsen burners and test tubes are deliberately avoided.

Guidance is given on carrying out the activity under the heading 'What to do' and this is often illustrated to ensure clarity.

Having done the activity some 'Review' questions are asked. These are designed to both direct the user's attention to important points and to help them remember key ideas.

The user is then directed to a 'Commentary'. To see the writer's commentary on the answers they have given, the user must first click the 'commentary' icon to move to another page. This is to aid the user in working out their own answers to the review questions before reading the writer's response. The commentary may give essential information on important scientific and technological principles or may refer to important teaching principles behind the suggested approach.

The term 'commentary' was very deliberately chosen rather than the term 'answer'.

Although evaluations of the previous material showed that teachers were unhappy with a totally open-ended approach, it was felt inappropriate to suggest, especially in a science and technology programme, that the authors knew all the 'answers'! Instead, we chose to comment on the review questions on the basis of our own experience or to indicate the current views of the scientific community.

A feature frequently requested by teachers using the previous *Success with Primary Science and Success with Primary Technology* material was that ideas should be offered for applying the principles just learned in the classroom. In response to this, the TechnoScience 2000+ activities often include a section headed 'In your Classroom', that aims to illustrate the classroom relevance even to young children. This latter point was also raised by many teachers who felt that little advice was usually offered on how to approach the teaching of science and technology with younger children, say between the ages of five to seven years.

Not only is this feature helpful to teachers in their day to day teaching, but there is evidence to suggest that far more is learned from in-service work when this is applied in the classroom (Eraut, 1982, 1994).

After offering a suggestion on a teaching procedure we may follow this with a 'discussion' of the classroom application. This will relate to the writers' experiences of doing this in our own classrooms. It is important to stress, however, that although many classroom-related activities are included in the materials, these materials are designed to be used by teachers – they are NOT children's learning materials! Where classroom-related activities are suggested we emphasise the importance of the teacher, who knows the needs and abilities of their own students best, always adapting the suggestions to suit those particular children.

Since the teachers using the materials will of necessity have a wide range of knowledge and experience of science and technology and of the teaching of these subjects, a facility is offered to those who wish to pursue their knowledge further on any particular issues. In these cases more detailed information is available on certain topics in the special section called 'Background Information'. This section may be accessed at any time, and from any point in any module from the side menu bar that is constantly on view. In some instances this may also include hyperlinks to other informative web sites and this database of information will be constantly added to – both features only possible with an Internet-based programme.

A key element in promoting scientific and technological literacy world-wide is ensuring that the science and technology being studied is seen to be relevant to and important in the everyday life of the student – of any age. Only by ensuring a high level of student involvement and a high degree of student motivation will this be achieved.

The activities suggested in TechnoScience 2000+ are designed so that, after suitable adaptation by the teacher, their students will have the greatest possible degree of involvement. In order to achieve this, however, the teacher must be fully confident in both his/her own understanding of the ideas and applications involved and be clear in their own minds how to successfully carry out the activities in the classroom.

This, undoubtedly, poses a problem in the design of the material.

On the one hand, the teacher requires clear guidance on what is required and how to carry out an activity successfully. On the other hand, this degree of direction can lead to 'formula' teaching in which the students are required to carry out set procedures by the teacher. For this reason it is essential to stress again and again the absolute necessity of the teacher adapting the activities as presented. This is a key issue in the 'Teaching Issues' modules where guidance is given on presenting the students with problems based on issues of real relevance. Some of the ideas within the activities may then be selected where appropriate to assist students in successfully solving problems arising.

Throughout the material real-life examples are illustrated that may be drawn upon in providing ideas for introducing issues of genuine relevance to the students. For example, the question might arise as to why an egg white that is normally a clear, viscous liquid, should turn to a stiff white material simply by whisking. The module dealing with mechanisms thus has a section in which the form and function of kitchen implements, including whisks is examined. The teacher faced with this issue can then use the module to ensure that they have all the information needed to understand the functioning of gears or other mechanisms that may arise from the topic. In addition they will be provided with ideas to use in helping the students to gain the maximum benefit from pursuing the topic and developing the relevant scientific and technological understanding. Should the teacher wish to pursue further their understanding of the process of colloidal denaturation involved, then this information is available in the 'Background Information' section.

Although the material is designed for, and best used, on the computer, in order to make the material accessible to as wide an audience as possible, especially in countries where computer access is not widely available, we felt it necessary to make the material available in a form that may be printed. To this end, in the introduction to every module there is an icon that makes it possible to download the entire module as a pdf file for printing. Although the copyright of the material rests with the authors, permission is granted for teachers, STA's or administrators to download and reproduce the material freely for educational use. Vigorous legal proceedings would, however, be taken against anyone who reproduced the material and tried to sell it at a profit.

This presentation/workshop will provide detailed guidance on the form and use of TechnoScience 2000+ and will enable delegates to gain hands-on experience of the materials.

A significant aspect of the workshop is that it provides delegates with an opportunity to discuss the format, presentation and application with the authors.

From these discussions the material can be updated where necessary but, more importantly, those groups or STAs who may wish to develop local versions to suit the curricular and culture of other countries will be able to draw on the experience of the authors in promoting such developments.

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Preparing Future Citizens for Laser Technology

Simon George, California State University, USA
Herbert Gottlieb, City College of New York, USA
georges@csulb.edu, herbgottlieb@juno.com

Both high school and college physics instructors throughout the world are developing new ways for using low-power lasers in their lecture demonstrations and student laboratories. After a brief introduction that presents the basic theory of operation of gas and visible diode lasers, a 20 minute video is shown. This includes a short history of laser development and features some of the primary applications of lasers for research and industry.

Several of the better laser demonstrations for motivating students are performed.

1. Laser beam communications using international Morse code

A beam from a low-cost solid-state laser pointer is aimed at a distant solar cell connected to an audio amplifier. The beam is interrupted momentarily using the demonstrator's fingers to produce a string of dots and dashes spelling words such as "H E L L O":

"..... . .-.. .-.. —- "

2. Fibre optics transmission of data and audio signals

The beam of a laser pointer is amplitude modulated using the output of a small tape recorder and carried by a length of fibre optics cable to a receiver consisting of solar cell connected to an audio amplifier and speaker.

3. Interpretation of modulated laser beam sound patterns

The beam of a laser pointer strikes a small mirror that is cemented to a rubber diaphragm stretched over the mouth of an empty coffee can. The reflections of the laser beam from the mirror are aimed at a distant wall of the lecture room. When the demonstrator speaks into the opening at the opposite end of the coffee can, the compressions and rarefactions of the air inside the can vibrate the mirror causing the reflected laser beam to form complicated lissajous patterns on the distant wall. The distinctive patterns formed by vowels such as "A", "E", or "O" can be easily recognized.

4. Sawing a laser beam into segments using a simple laser beam cutter

The beam of a laser pointer is aimed at a distant receiver consisting of a solar cell connected to a low-cost audio amplifier and speaker. When the teeth of an ordinary pocket comb are moved rapidly across the laser beam, the interruptions that are heard sound like a saw cutting a log of wood. Pieces of the cut laser beam are then passed around the audience for their inspection at close range.

5. Laser disintegrator

Approximately 50 milliliters of water are poured into each of two Styrofoam cups. One of the cups is then exposed to a laser beam for exactly five seconds. Then both of the cups are inverted. Observers see that all of the water spills out of the unexposed cup but nothing comes out of the cup that was exposed to the laser beam. Apparently, the water was disintegrated by laser electrolysis.

If difficulty is experienced when performing this experiment, it is suggested that the demonstrator try again but this time be sure to remember that a dry sponge must be hidden in the cup that will be exposed to the laser beam.

6. Measuring the index of refraction of transparent solids and liquids

The index of refraction of various solids and liquids can be measured in the student laboratory by aiming a laser pointer at the surface of the material. After measuring the angle of incidence (I) and the refraction (r) that the beam forms with the normal to the surface, the index of refraction (n) is calculated using the relationship:

$$n = \sin I / \sin r$$

7. Reading bar codes that are printed on letters and packages

The beam of a laser pointer is slowly swept over a large bar code at a constant speed. As the beam passes over the white bars, reflected pulse of light are observed. In a bar code scanner, the duration of each of these reflected pulses is measured and a computer interprets series of such pulses as meaningful letters or numbers.

At the conclusion of the demonstrations, a raffle is conducted and the lucky participants are awarded lasers and laser accessories that they can take back home after the conference

More than 100 additional laser demonstrations by the presenters of this workshop symposium can be obtained without charge from the Metrologic WEB site of the computer internet.View and download them from your internet WEB server using the address: http://www.metrologic.com/edu

When the first menu appears, click on "PRODUCTS" at the left side of your screen.

When the second menu appears, click on "TEACHERS BREAK ROOM":

When the third menu appears, click on "FUN WITH A LASER"

When the fourth menu appears, click on "101+ EXPERIMENTS"

Simulation Based Authoring Software for Physics Teaching

Alberto Florentin, Secondary Education, Cyprus
albertos@spiderent.com.cy

The usefulness of computer simulations in the teaching of physics is not under question. The multitude of Java applets appearing on University sites is one testimony to this. Simulations are considered to lead to a "greater intuitive understanding of physical concepts"[2], to enhance student's problem solving skills and refine their higher-order thinking strategies [5]. These are all objectives central to contemporary thinking on the teaching of physics [3]

I have been programming computer simulations intended for physics teaching (highschool level) since 1994. Since then, I have had the opportunity to discuss the use of simulations in physics teaching with many physics teachers in Cyprus, both informally and formally in training sessions (conditions up to now did not permit a comparable amount of class use). It was mainly through those discussions, as well as because of the prevailing style of educational computer programs circulating in the Greek and Cypriot market (in contrast to those coming from abroad), that I realized that the following categorisation of computer simulations is important, and not well understood by teachers in Cyprus.

Computer simulations can be distinguished as belonging to two different types, which serve to achieve two different objectives in the teaching of physics:

The first type serves as a substitute for laboratory experiments, when the phenomena to be studied are too fast or too slow, or the experiment is too dangerous or too expensive or for other reasons impracticable. It follows that their goal is to imitate "reality". I think of this as the "Flight Simulator" or "Virtual Reality"[1] mode of use. It can be argued that an aim for the authors of this type of simulation is the so-called "suspense of disbelief" effect in literature and theater (what I am reading or seeing is really happening, not an artifact somebody made up, and so I can become involved and emotionally affected by it). The fact that the user may "forget" that what she or he is seeing is not a real physical situation but a computer model, is not regarded as a problem, it may even be desirable

This has implications for the needs of the software produced, in terms of graphics, animations, speed etc. and demands heavy use of what is called "multimedia" technology.

In my experience this is what many physics teachers expect from all computer simulations. That means that they often treat them as a substitute for laboratory experiments, concentrating sometimes on numerical data gathering by the students instead of trying to achieve qualitative understanding of the subject being taught.

While this type of simulation is indeed useful, I think that the next type of simulation is also important.

For this second type, an explicit physical-mathematical model is ported to the computer, and can be "exercised" by the user by changing initial conditions and other parameters to produce simulations. Simulations are in effect the numerical results of a big number of calculations [2]. However a useful computer simulation crucially adds graphs, animation and various other visualization methods to help the user make sense of those numerical results [1, 2]. I think of this as the *model oriented* use of simulations. The model itself is usually not a "realistic" one – not (only) because of computer or programmer limitations, but on purpose: the simulation is the "exercise" for purposes of exploration and understanding of the implications of a simple scientific-mathematical model. A more realistic and thus more complicated model would defeat that purpose.

It follows that in this mode of use of simulations, "suspense of disbelief" is undesirable. Consider for example a simulation of projectile motion, with no air resistance included in the model, or surface waves propagating without attenuation. It would be wrong for the user to be under the impression that this is a correct representation of physical reality.

MODEL AND SIMULATION

Moreover, the user should be given the chance to develop "insight", even limited, into how the computer works, i.e. to become aware of the underlying mathematical model which is exercised, and its ommissions and limitations compared to the real physical system being simulated . A basic goal that could be pursued with the use of this type of simulation is that it should help the user use the software in constructing for her or himself a mental model "equivalent" to the one used by the simulation. In addition, the importance of simulations in physics means that if possible they should be presented to the students as more than just a teaching aid, as in fact a fundamental method of physics [2, 6], and if their "internals" can be made more visible, so much the better [7].

"*Mental models ... consist of propositions, images, rules of procedure...*"[3]. I believe that model oriented simulation software, to help students construct mental models, should have an attractive but simple interface – a complicated "realistic" background, designed to suggest a real world situation will not help based on abstraction mental model formation.

If the purpose of the software is to help the user construct a mental model, then a limited understanding of how the computer works – that there is an underlying mathematical model being exercised – is useful. While the need for attractive graphics and effective animations is not less than for the "virtual reality" type of simulations, their orientation and style is radically different (although it can be argued that both types of simulations can be accomodated in the same piece of software [8]) and different criteria should be used for graphics and animations. That is, it should be made evident that the images appearing on screen are not images of real physical objects, but abstractions, symbols of those objects, and of other objects that are part not of the physical reality but of the model (for example, vector quantities and "light rays"). There should be *"definite rules of correspondence between the physical system and the model representing it and, at the same time, an explicit distinction of the model, which is usually simplified and the real system, which appears singularly complicated"*[8]

This paper will propose a structure – simulation based authoring software – for model-oriented educational simulation software and present two such programs produced by the author.

MODEL ORIENTED SIMULATION SOFTWARE: EXPENSIVE TO PRODUCE, AND/OR MODIFY

It takes lots of specialized human-hours to produce model-oriented software for educational use . Unfortunately, it is not easy to put a good program to good and effective use. While many of us enjoy, and even benefit from exploring physics simulations by changing parameters, it is not as easy for students as well as for many teachers, to engage in such activity. It is time-consuming for the beginner, and can become frustrating.

For that reason a "pure" simulation program, that is a program with only the facilities to control parameters, "run" the simulation and get information (either numeric or visual) on the evolution of the system, is not enough for student use. In fact, it is usually not even suitable for classroom presentations, if choosing the right parameters to display what is needed takes minutes instead of seconds. To solve that problem, some simulation software has facilities for saving to disk specific simulations. Even then, it takes some preparation to retrieve the right file in the right time.

Typically simulation software for education either includes text together with some ready-made simulations (hard-coded or saved in some form sets of initial conditions), and comes or is supplemented with printed material including instructions for activities and worksheets. In other words, its use follows the guided discovery approach [5] as opposed to unguided exploratory activities.

However, we should keep in mind that different students learn in different ways [3]. Even if a strategy for use is chosen, say guided discovery, that strategy can be implemented in many different ways, which can be appropriate for different situations, like different types of students, or teacher prefferences, or, and this is I think significant, after insight gained and problems identified from feedback from use of the software in the classroom.

Do we need a new set of software for such cases? Producing a new set of accompanying printed material can solve the problem of course. In cases like this, is the disadvantage of printing, distributing and working with new and different worksheets unavoidable? What is more, working through printed material does not solve the problem of managing simulations where a large number of parameters should be changed to create different starting points suitable for exploration.

SCENARIOS – "REUSABLE" SOFTWARE

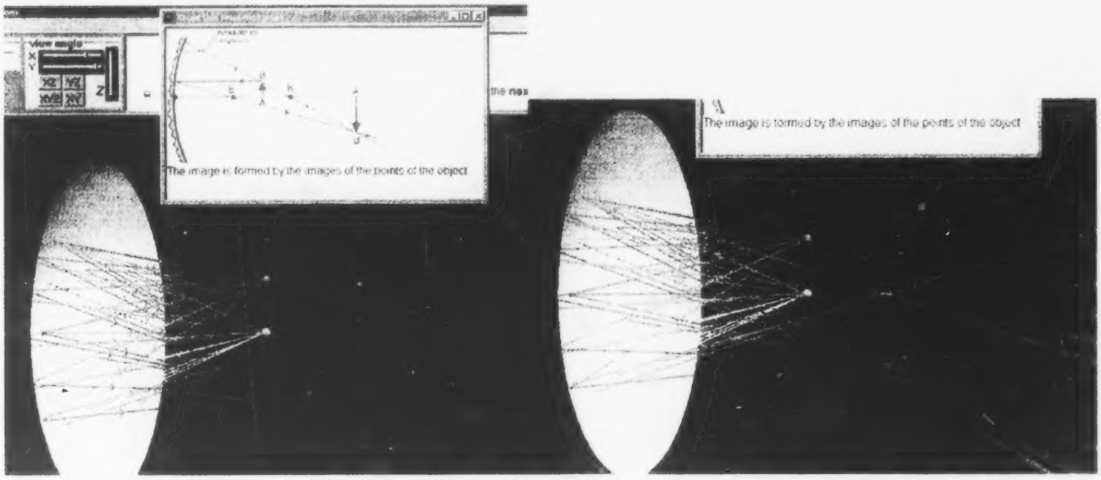
As I became aware of these problems, I tried to develop a technique for dealing with them [4]. I now use a program structure, which consists of connecting a simulation engine with sequences of saved initial conditions and other parameters combined with accompanying text and graphics. (It is also possible to include sound and video). If we call each element of the sequence a page, then the user can a) follow the sequence page by page. S/he can now change parameters at will after navigating to any page, or go straight to the next page after activating and working with the simulation page. b) Select at random pages from a list, and of course change parameters or c) select a different sequence from a list of available sequences.

We can think of such sequences as *scenarios*, different ways of going about presenting the material, either in class or for individual use. To solve the problems mentioned above, scenarios should be easy to produce. The scenario writer (a teacher or an educational unit or group) must first provide an access code – we don't want students changing the scenarios. Then s/he can add a new "page", choose and test the desired parameters, write the text in a special window (text formatting and the insertion of graphics or video can be done in MS Word running in parallel and then copied/pasted in the programs text window), choose, if wanted, additional scenario-specific parameters like autostarting the simulation or including a multiple choice question. Then s/he must choose an index number, which will place the page in the desired position in the sequence, instruct the program to save it, and repeat the steps.

Scenarios should be equally easy to edit. The scenario writer provides the access code, uses the list to move to each page s/he wants to change, makes changes to the automatically retrieved parameters and text, and saves them.

Additionaly the student can save simulations on a one file per simulation basis without any special access codes, as can be done in other simulation software. These could be solutions to given problems, which could be given to an instructor for evaluation.

We can add new scenarios at will (they are database files, and new ones can be included in the program together with their description by editing a simple text file). We can therefore produce different scenarios for class presentations, guided discovery, review or testing.



The image is formed by the images of the points of the object

The image is formed by the images of the points of the object

A page in a scenario relating two different representations of the geometric optics model. The two point sources in the simulation window have different colors, and so do the top and the base of the "arrow" on the upper right text window, which shows the traditional geometric algorithm for finding images. The semi-transparent spheres in the simulation indicate the position of the images as computed by the program with the same method as in the pencil-and-paper mode. The rays are animated to move from the light sources to the mirror (left image), become reflected and continue by passing through the image position (right). Notice that the lower image's position does not coincide exactly with the intersection point of the rays. The text window could also be used to carry a photograph of a convex mirror producing a real image on a screen, to connect the real physical system with the model.

Of course scenario writing can also be time-consuming and demanding. But I suggest that it may be a relatively cheap, quick and more flexible method available today to take advantage of such simulations in education. It is, to borrow a phrase from software engineering, reusable software.

Conditions have not made it possible to equip my scenario-enabled programs with a collection of complete scenarios. After all, my aim was to make it possible for teachers with no programming knowledge to produce the scenarios, while the programmer goes on to produce the next scenario-enabled simulation. Unfortunately, this "scenario" has not yet materialized, and also no time was made available to me by the Ministry of Education to produce new simulations in the last two academic years. The simulations I present here were produced entirely on my own time.

Managing Complexity through Scenarios

In many subjects taught in physics, the ability to mentally handle images in three dimensions is both difficult and important. Computer programs that render three-dimensional images (with the ability to project to coordinate planes effectively linking the two dimensional images we use in books/on paper sketches/on the blackboard with an essentially three dimensional model) can help overcome related conceptual difficulties. If those programs are model-oriented simulations, and we can change parameters at will, that should make them even more effective.

However, there are problems to the use of such programs in the classroom. As I remarked before educational simulations are more effective and flexible the more they are parameterized. But choosing and changing parameters during class time for broadly parameterized simulations can be even more complicated and time-consuming than it already is for many 2D simulations. Long-time users of modern software like the MS Word for Windows I am using to write this contribution, can appreciate the problems this trend to more complicated "better" programs, with more and more facilities-parameters added in each new version, has created.

simulation-based specialized authoring system

As I described above, the solution I have attempted to introduce in my programs, is what can be called a *simulation-based specialized authoring system*. This involves storing simulation parameters and relevant text/graphics in a sequential scenario. The teacher can either prepare a new scenario or, more realistically for today's overburdened teachers, choose from a collection of such scenarios. These could be used for classroom presentations or used by students to go through the material (hopefully with frequent stops in order to engage in what-if exploration by changing parameters in interesting pages), with multiple-choice questions or other activities included. It is also possible to select scenario "pages" as required from a list, instead of following the scenario sequence, and to save student-constructed simulations (specific sets of parameters) to disk for later use.

Since the students are able to make changes to those parameters at any time, interactivity is not diminished compared to other simulation programs. In fact, going through some "scenario" pages and noting the parameter values can serve as a good introduction to the why-and-how of parameters in the simulation. Parameter changing is also less time-consuming than starting from scratch, since users can change parameters starting from a similar simulation to the one they want, reached by moving sequentially through the scenario or selected from a list.

I will present two such programs:

1. Charged particle in Constant Electric and Magnetic Fields

Movement of a charged particle in constant electric and magnetic fields

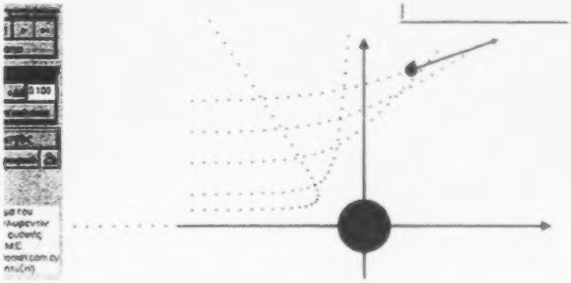
(Includes spiral movement in magnetic field, alone or in combination with electric field)

Movement between charged parallel plates (1 or 2 systems)

Trajectories of two charged particles

With Center of Mass motion

Can simulate principle of Rutherford experiment, by keeping traces of charge movement in successive scenario pages



In addition, in two dimensions, dynamic and isopotential lines of fields produced by 2 charges, with field intensity vector visualization by mouse probe

2. Geometric Optics: Spherical mirrors and lenses

Students often fail to understand the model of image creation by mirrors and lenses based on the images of point or parallel light sources and the paths of the rays belonging to them. Instead they just learn to reproduce the well-known ray diagrams and formulas to find the position and characteristics of images. The simulations in this program concentrate in making the above-mentioned model understandable, and in connecting the ray diagrams and formulas with it.

Ray and photon animation based on diverging/converging/parallel beams and their interaction with mirrors and lenses. The radius of curvature of mirrors can be dynamically (push-button) changed, and both mirrors and lenses can dynamically "glide" along their principal axis.

Image creation can be explained by using sets of colored point light sources.

Optical errors in mirrors and lenses, and the magnitude of these errors under different conditions (excluding, in the present version of the program, chromatic aberrations and the implications of the different refraction indices of different wavelengths) can be easily demonstrated. The simulations also handle possible total reflection in lenses.

Selecting options on what to show on screen. The reflected ray projections feature shows that parallel ray projections intersect *near* the main focus – which is also selected and shown as a little red sphere.

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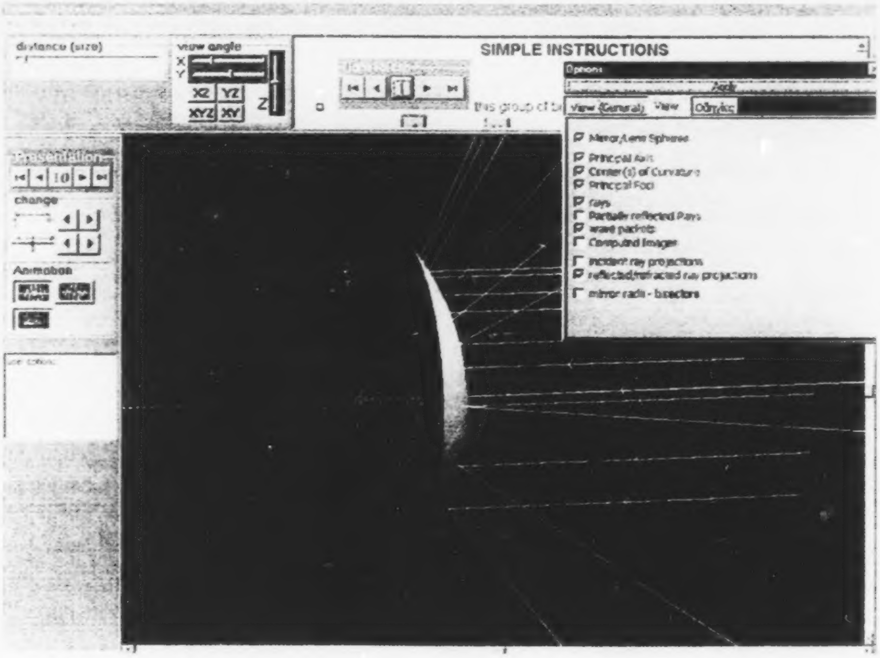
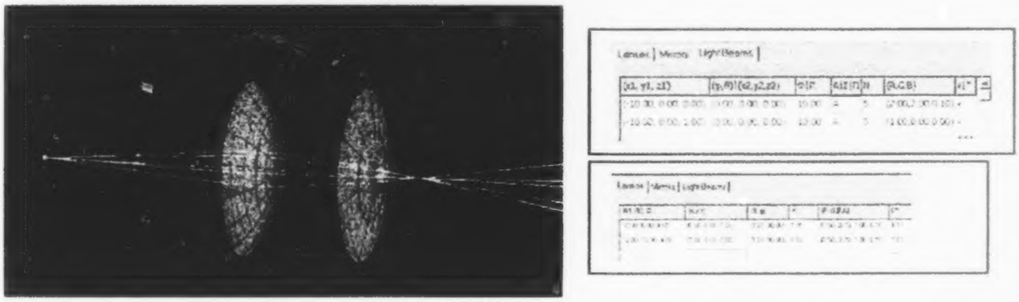


☑ Mirror/Lens Spheres
☑ Principal Axis
☑ Center(s) of Curvature
☑ Principal Foci
☑ rays
☐ Partially reflected Rays
☑ wave packets
☐ Compound Images
☐ incident ray projections
☑ reflected/refracted ray projections
☐ mirror radii - bisectors

Both programs have a "selection" feature which gives information on any objects that the user clicks with the mouse. "Dragging" with the mouse rotates the images, so that students can exercise their spatial perception. Projecting to XY, XZ, YZ planes can be used to compare with 2D drawings.



Two lenses, two diverging beams, and the parameters saved. The user can now make changes to those parameters and observe the outcome.

CONCLUSION

An iterative series of scenario production, using the scenarios in class, and editing or creating new scenarios based on feedback and research will make it possible to evaluate if this way of using simulations can benefit students qualitative understanding and model construction. I am also presently working on connecting the simulations with hypertext (again possible to be produced by a non-programmer on a tool like FrontPage, and hooked to an existing scenario), so that this mode of studying can also be accomodated by the same simulation engines.

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Natural Electrical Circuits: Hands-on Science and Technology Activities

Muhamad Hugerat, Salman Aliyan, and Sobhi Basheer
The Arab College for Education in Israel, Haifa, Israel
mhugerat@yahoo.com.

Key words

Laboratory activities in scientific domains in elementary schools contribute mainly to three domains (1,2):

1. Thinking and studying new domains, such as:

A. Developing a positive approach to science.

B. Encouraging the pupils to recognize and investigate the environment

C. Encouraging curiosity, initiatives and develop scientific cogitation.

D. Developing skills and tools for investigation.

2. Developing social aspects in pupils.

3. Developing and strengthening the personal security.

In this work, several scientific activities will be presented for elementary school pupils. According to our observation results this kind of laboratory demonstration helps the children to explain natural phenomena, ponder and study other similar scientific experiments (1,2).

I. Electrical Circuits using Food Stuff as Electric Cells

In the following experiments, an electric current will be generated by using two electrodes stuck in a body of fruit or vegetable (or dipped in their juice) (3). The generated electrical current will be used to light a bulb or a light emitting diode (LED).

Materials: DC microamperometer, lemons, a strip of aluminum and another strip of copper (10 cm long each), and an LED.

Procedure: Squeeze a lemon by your hands through pressing the peel to release the juice inside the body of the lemon. Insert the strip of copper and that of aluminum about 5 cm in depth in to the lemon so that they are close to each other but not touching. Connect the strip of copper with one side of the microamper and the other side with the strip of aluminum.

Lemon juice in this experiment can serve as an acid used in conventional batteries, while the copper and aluminum strips are dissimilar metals. Under these conditions, citric acid in the lemon reacts differently with the two strips of metals. As a result of these different reactions a positive charge will be produced on one metal while the other metal will be negatively charged (3). In this system an electric current will be generated once the circuit is closed. The closed electric circuit is capable of generating small amount of electricity to flow, which can be measured by an electricity detector. It can be observed that one lemon cell is not adequately strong to light up an LED. Therefore, when several lemons are connected together in series this will enable lightening an LED. Other fruits and vegetables can be used instead of lemon for constructing the electric cell. Also, different metal plates, such as, Zn, Ni, Ag, Al, Mg, C, Pb and Sn, in various combinations can be used to obtain the highest output current or voltage in order to light up an LED. Furthermore, different juices in a cup can be used instead of vegetables and fruits (Fig. 1).

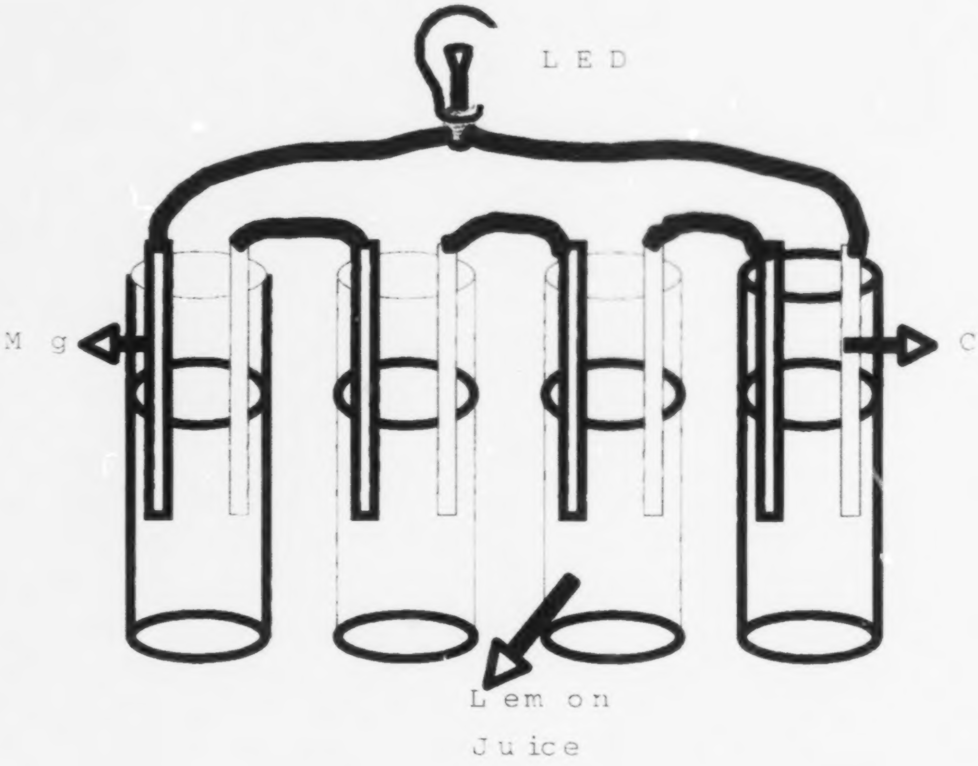


Fig. 1: Electrical Circuits using lemon juice as Electric Cells.

II. Electrical Circuits with Human Bodies.

In the following experiments, human body can serve as a bridge of salt and therefore it facilitates the flow of electricity in a cell composed of two different metals that are connected to a microamperometer. This experiment can be demonstrated as follows: Connect a copper plate and aluminum plate each to one side of a microamperometer. When you hold one of the plates in one of your hands and leaving the other plate aside there will be no indication to an electricity flow by the microamperometer. However once you hold both plates each in one hand there will be indication for electricity flow in the circle. These phenomena can be interpreted for the pupils as the following. In normal conditions, palms contain salty dampness that is excreted from the body. Therefore, under these conditions, the salty dampened hand on one-side removes negatively charged electrons away from the copper plate and leaving positively charged behind. While on the other side, the salty dampened hand transfers electrons to the aluminum plate and leading to convert it to a positively charged plate. This difference in charge between the two plates creates a flow of electrical current. In this demonstrated experiment, our body serves as a medium for transferring negative as well as positive charges in the above constructed electrical cell. Decreasing the resistance to the current lead to increasing the flow of electricity through our body. Therefore, wetting our hands before the experiment with table salt solution will cause a significant increase in the electricity current in the cell. Different electricity switches for the constructed electrical cell can be also demonstrated for the pupils. In the first case, one pupil holds the two metal plates each plate in one hand to represent the closed circuits. When the pupil holds only one plate and leaving the other plate aside this case will represent a non-closed electricity circuit. In the second case, two pupils whereas each of them holds one metal plate in his hand. When both pupils shake hands the electricity will flow and therefore, this will represent a closed electricity switch. When both pupils are not in touch this case will represent a non-closed switch.

In this regard, another experimental activity can be demonstrated for the pupils where a human body serves as a salt bridge in electrochemical cells. In these experiments, two different metals each is dipped in a salt solution are connected with each other via wires to a microamperometer. Pupils will observe that under these conditions there will be no indication for electrical current in the system. However, when a pupil insert his hands, each in one of the salt solutions, it can be observed that there is an electrical current flowing in the system. Under these conditions the electric circuit is closed where the human body servers as a salt bridge. The same experimental system can be operated without a salt bridge by decanting one of the salt solutions into the other salt solution keeping both metals dipped in both salt solutions. Under these conditions, the water stream serves as a salt bridge and the electrical circuit is closed.

Classifying metals according to their conductivity

Pupils to classify different materials according to the electricity conductivity can use the aforementioned experiment. This task can be demonstrated for the pupils as the following procedure (Fig. 2).

Attach one side of the microamperometer with a wire connected to a copper plate. Hold the copper plate in one hand while keeping the other piece of material you want to test in your second hand. Connect the piece of material with the wire in the second side of the microamperometer and read the value obtained on the scale. Repeat the same procedure by changing the material you want to test (Fig. 2).

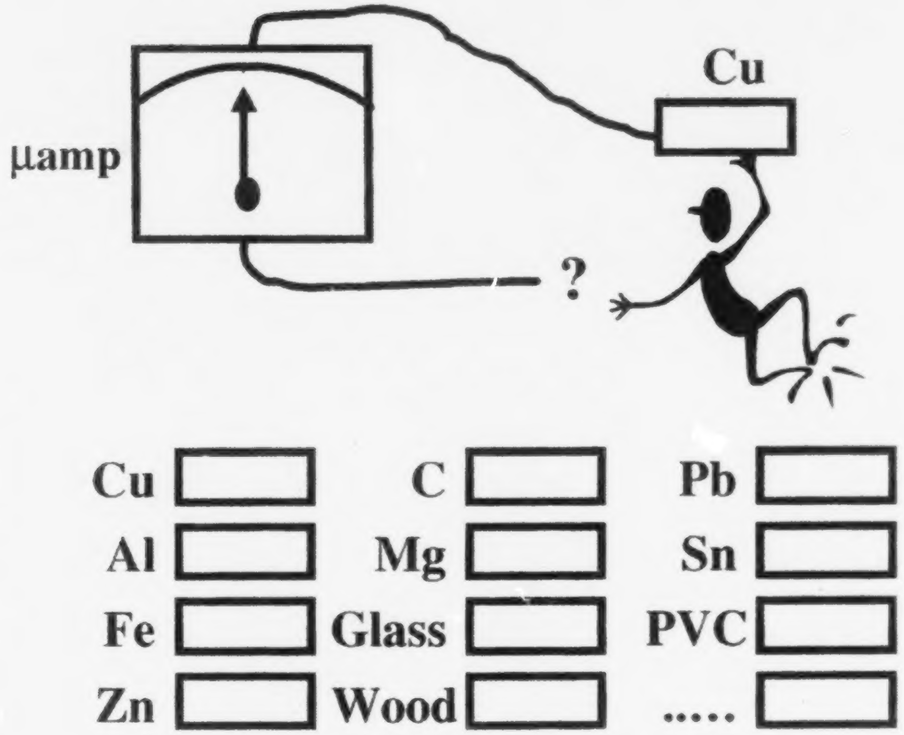
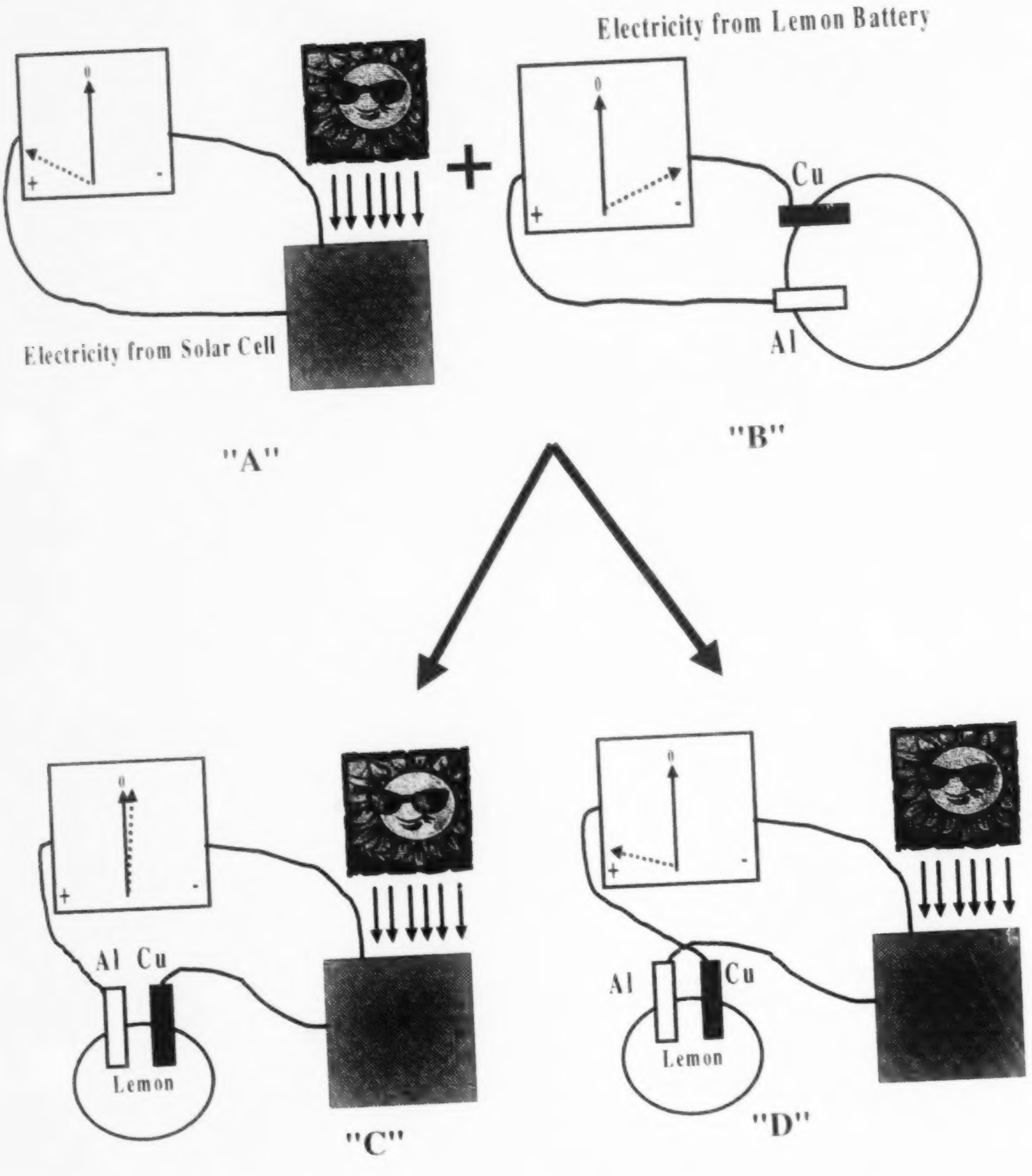


Fig. 2: Classifying metals according to their conductivity.

III. Electrical circuits using photovoltaic cells

The main disadvantage of photovoltaic solar cells is expressed in their low yields to generate electricity (4). photovoltaic solar cells are composed of very thin layers of silicon. A basic low of the nature is that similar charges repel each other and therefore the electric current will be zero, while unlike charges attract each other and they create an electric current. The following experiments demonstrate that similarly charged electric currents could be summed while opposite charged electric currents could cancel each other. As it can be seen in Fig. 3A, when the photovoltaic solar cell is connected via a wire to a microamperometer, the arrow of the scale will move to the positive side (5). This phenomenon indicates that the photovoltaic solar cell absorbs light and converts it directly to electricity. On the other side, when a lemon connected with a wire of aluminum and a wire of copper and both wires connected too a microamperometer each wire from one side, the arrow of the scale will move to the negative side (Fig. 3B). When both electrical cells are connected together in series, one electrical current will cancel partially the other current (Fig. 3C) (5). However, when the wires, which are connected to the microamperometer, will be replaced with each other in the aforementioned system, the arrow of the scale will indicate that the current has become stronger and more positively charged. The pupils can repeat the same experiment however instead of the lemon battery a human body with the hand battery can be used (5).


Electricity from Lemon Battery
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A Hands-on Approach in the Learning Process of Technology

Marcelo Caplan, Keith Kostecka, Gregory A. Neul,
and Zafra M. Lerman,
Columbia College Chicago, USA
Avi Schwartz,
Technion City, Haifa, Israel.
micaplan@prodigy.net, ZafraL@aol.com, nthofstn@wis.weizmann.ac.il

In order to guarantee science and technology education for all, we developed at the Science Institute, in cooperation with TED, an innovative curriculum based on students' previous knowledge and daily experiences with technological devices as the starting point for further investigations and innovations.

We teach from the concrete to the abstract, from the relevant to the non-relevant. Students are familiar with everyday technology such as cellular phones, speakers, fans, electronic keyboards, audio systems, etc. With the help of TED kits, students are able to define a problem and implement their own technological solution, while fully understanding the basic science involved. To implement this methodology of learning technology, we have developed technological kits which take into account three important factors of the learning process: the students, the teachers, and the facilities in which the class takes place.

Various TED kits were developed to facilitate the student centered instruction. These kits move from simple to complex concepts using devices such as communication systems, control systems, digital systems, and others. Groups of 2–3 students work in a collaborative manner, progressing at their own pace, and encouraging individual advancement of each student.

To allow each group to learn at its own pace, each activity is divided into several tasks, which proceed from the simple to the complex. Thus, the students will complete tasks according to their own capabilities, and will acquire the skills necessary to undertake the more complex tasks.

The teacher plays a significant role in this methodology. He or she needs to act as a facilitator, and allow the students to proceed through the learning process. The teacher works with the students individually and in groups. The teacher assesses the capabilities of each group and develops a work plan compatible with each groups' needs. This approach permits the introduction of topics and concepts in ways that make the learning process more accessible and interesting. In this role, the teacher creates a positive environment in which the students will find their own answers to questions, and not depend on the teacher as the source of all the answers.

To implement technology instruction, it is not necessary to build a special space or laboratory. Each classroom is suitable to the learning process of technology when using the TED kits. The kits are self-contained in durable carrying cases; they can be transported from classroom to classroom easily. The set-up of the technological classroom is not time consuming, which allows teachers to optimize the use of their time in the class.

Based on all the factors mentioned above, the students participating in these kind of technological hands-on activities are exposed to real world problems. They enjoy being active in the investigative process, and they become very excited to produce by themselves technological devices.

Students build an array of devices ranging from flashlights, electrical fans, and simple keyboards in the elementary level; to light dimmers, telephone switching systems and traffic light controls in the advanced level. Students' evaluations show that they appreciate learning math and science while building these technological devices.

In order to encourage teachers from elementary and high school to become enthusiastic in the teaching of science, mathematics and technology, we conduct workshops in which they engage in technological problem-solving activities, using TED kits to provide a solution for the presented problem. This method has been successfully used in teacher workshops in Israel, England, Brazil, Argentina, Chicago, Panama, Jordan, and the Palestinian Authority.

These kits were utilized also in parent workshops; these parents came from diverse academic, economic and ethnic backgrounds. They expressed interest in having these kits at home to work with their own children, their children' friends, and with other parents who were unable to attend the workshops.

Working with TED kits in their own classrooms, teachers become a guide on the side instead of a sage on the stage, allowing the teachers to work with each student in a one-to-one basis. During this process, students develop critical thinking and problem-solving skills.

Examples of the use of TED kits will be presented, and the audience will be given the opportunity to build simple technological devices.

The Place of Biotechnology in the Teaching Activity at School

Petia Genova and Kamelia Staikova, Sofia University, Bulgaria
petia@biofac.uni-sofia.bg

The process of intensive development of biotechnology is reflected in the teaching activity at school.

This article is to define and describe how biotechnology is presented in the school curriculum on biology.

The biotechnology are part and parcel of the curriculum especially in the optional subjects.Three different modules are offered to the pupils:

1. Bioinformatics and Bioelectronics
2. Biomanagement
3. Laboratory biotechnique

The object of the curriculum of the first module is to introduce initial notions and fundamental ideas of the appliance of informatics and microelectronics in the field of biological sciences.

The second module is connected with the learning of the basic notions and the major methods and principles of biological sciences.It is the subject of this programme to build up a fundamental idea of the specific appliance of management of the sphere of biology and biotechnology.

The purpose of the third module in the teaching curriculum is to initiate the pupils to the basic principles of the methods which are mostly used in laboratory practice.This module is divided into two parts:the first part is concerned with three different trends: analytical, preparative and biotechnological;the second part includes clynical and medical bias.

The teaching of the subject matter of the curriculum requires an integration with the teaching curriculum of the University, Scientific institutes and other structures concerned with the problems of biotechnology, informatics and bioelectronics.

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